FRACTION MODERN: MOLECULAR CARBON SPECIATION ACROSS A PERMAFROST THAW CHRONOSEQUENCE

ELIZABETH K. COWARD[1*], TYLER D. SOWERS[1], RUCHA P. WANI[1], DONALD L. SPARKS[1]

[1]Delaware Environmental Institute, Univ. of Delaware, Newark, DE 19716-7310, USA (*correspondence: ekc@udel.edu)

Permafrost soils contain vast stocks of organic carbon (C) stabilized during Pleistocene glaciation that are increasingly susceptible to decomposition and export as dissolved organic matter (DOM) under increasing climate warming. While the composition and lability of surficial active-layer permafrost thaw is now well-elucidated, most C currently stored in Arctic soils is locked in deep Yedoma deposits. Thawing of these frozen reservoirs poses the greatest threat to climate forcing, yet the molecular composition, lability and reactivity of C in permafrost soils across the diversity of thaw regimes present in Arctic systems remains unknown.

To explore the coupling between molecular composition and temporal persistence in across depositional environments, melt- and soil-derived DOM samples collected from a chronosequence in Fox, Alaska were characterized via ultrahigh resolution Fourier transform ion cyclotron resonance spectroscopy (FTICR-MS), near edge X-ray absorption fine structure (NEXAFS) spectroscopy, and batch analyses. The chronosequence encompasses modern fully thawed, actively freeze-thawing and cemented Yedoma deposits from the United States Army Cold Regions and Research and Engineering Laboratory (CRREL) tunnel dating to 19, 27 and 33 ka.

Results indicate distinct molecular signatures in DOM composition across depositional and thaw gradients. In the oldest permafrost characterized with FTICR-MS, 33 ka DOM is comprised of a reduced, largely microbial signature of amino acids, lipids, and lignin-like moeities, providing evidence for in-situ degredation. With decreasing age, we observe increasing abundance of proteins and aliphatic structures in tunnel deposits. In contrast, actively freeze-thawing permafrost is dominated by terrestrial lignin-like and condensed aromatic compounds, suggesting such dynamic oscillations are reducing DOM complexity. Congruently, non-cycling thawed soils contain a diverse assemblage of hydrocarbons, lipids, proteins, and carbohydrate compounds. Observed variance in compound identity, abundance, and thermodynamic indices across the thaw chronosequence suggest permafrost C composition. Thus, the extent of thaw may mobilize discrete DOM populations, fractionated in lability and reactivity, throughout the warming Arctic.