Subarctic Lake Sediment Microbial Community Contributions to Methane Emission Patterns

Joanne B. Emerson[1,2*] (jbemerson@ucdavis.edu), **Ruth K. Varner**[3], Donovan H. Parks[4], Martin Wik[5], Rebecca B. Neumann[6], Joel E. Johnson[3], Caitlin M. Singleton[4], Ben J. Woodcroft[4], Rodney Tollerson II[1], Akosua Owusu-Dommey[7], Morgan Binder[7], Nancy L. Freitas[7], **Patrick M. Crill**[5], **Scott R. Saleska**[7], **Gene W. Tyson**[4], and **Virginia Rich**[1]

[1]The Ohio State University, Columbus; [2]Current affiliation: University of California, Davis; [3]University of New Hampshire, Durham; [4]University of Queensland, Australia; [5]Stockholm University, Sweden; [6]University of Washington, Seattle; and [7]University of Arizona, Tucson

http://isogenie.osu.edu

Project Goals: Our objective is to discover how microbial communities mediate the fate of carbon in thawing permafrost landscapes under climate change. Our team is engaged in a systems approach integrating molecular microbial and viral ecology, organic chemistry and stable and radiocarbon isotopes, and state-of-the-art modeling along an interconnected chronosequence of thawing permafrost and post-glacial lakes in subarctic Sweden.

Abstract: Post-glacial lakes in northern landscapes have been identified as a significant source of methane to the atmosphere, largely through ebullition (bubbling) of microbially produced methane from the sediments. Ebullitive methane flux has previously been shown to correlate significantly with sediment surface temperatures in these lakes, suggesting that solar radiation is the primary driver of methane emission. However, we show here that the *slope* of this relationship (*i.e.*, the extent to which increasing temperature increases ebullitive methane emissions) differs spatially, both within and among lakes. As microbes are responsible for both methane generation and removal in lakes, we hypothesized that microbial communities—previously uncharacterized in post-glacial lake sediments—could be contributing to spatiotemporal differences in methane emission responses to temperature. We compared methane emission data with sediment microbial (metagenomic and 16S rRNA gene sequencing), isotopic, and geochemical characterizations across two post-glacial lakes in Northern Sweden. With increasing temperatures, the increase in methane emissions was higher in lake middles than lake edges, consistent with higher abundances of methanogens in sediments from lake middles than edges. Using partial least squares statistical regressions, microbial abundances (including the abundances of methane-cycling microorganisms and of reconstructed population genomes) were better predictors of porewater methane concentrations than abiotic variables. These results suggest that microbial communities contribute to the rate and magnitude of the temperature response of methane emissions in subarctic post-glacial lakes.

Funding statement. This research was funded by the U.S. Department of Energy Office of Biological and Environmental Research under the Genomic Science program, Awards DE-SC0010580 and DE-SC0016440, in addition to a U.S. National Science Foundation REU program: Northern Ecosystems Research for Undergraduates (EAR#1063037).