IsoGenie: Microbes, ecosystem biogeochemistry, and climate change: dissecting methane flux in a thawing permafrost peatland in northern Sweden

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Project Goal: As permafrost thaws, increasing CH_4 emissions from northern wetlands are likely to cause positive feedback to atmospheric warming. The IsoGenie project seeks to discover how functional relations between biogeochemical processes, particularly methane production, and the underlying microbial community dynamics are affected by climate change-induced permafrost thaw. This goal is enabled by recent transformative methodological advances in both ecosystem science and molecular biology that allow high-volume tracking of isotopic composition of carbon gases, as well as the genetic potential and gene expression in the microbial communities which produce those gases.

To achieve this goal, we measured concentration profiles and surface fluxes of carbon gases (CH_4 and CO_2), along with their isotopic compositions, across a gradient in permafrost thaw from palsa (with underlying permanently frozen peat), to recently collapsed and flooded palsa dominated by *Sphagnum* spp. (intermediate thaw), to fully inundated sites dominated by *Eriophorum angustifolium* (fully thawed). At the same time, we sampled soil microbial communities in these sites to characterize composition, metabolic potential and gene expression. Both isotopic composition of carbon gases, and meta-genome/-transcriptome/-proteome data can be used to identify active metabolic pathways of methane production, and we hypothesized that the two methods would give consistent results. This poster focuses on biogeochemical and isotopic results, and a companion poster focuses on microbial community results (Mondav et al, "Microbial Communities Generating Greenhouse Gases in Thawing Permafrost").

Along this environmental gradient, from permafrost to fully thawed sites, the lability of the peat increases significantly as determined in incubations of peat material and monitoring of methane and carbon dioxide production rates. Coincident with this trend is an increase in methane surface fluxes and an increase in ^{13}C isotopic composition of methane (from ~ -80‰ in intermediate thaw sites to ~-65‰ in fully thawed sites) suggesting a shift in methane metabolism towards acetate fermentation and away from CO_2 reduction. We also observed significant temporal variation during the 2011 growing season in the carbon isotopic composition of methane fluxes, indicative of shifts in methanogenic and methanotrophic activity.

These observations will be used to test a biogeochemical model (the DNDC model) of methane production that includes alternative production pathways under different redox conditions.

Together, these initial results suggest that thaw-induced changes in hydrology and plant community composition increase peat lability, stimulating acetate fermentation and yielding increased methane emissions. We conclude that the biological controls on metabolic pathways of methanogenesis, though poorly represented in most ecosystem models, may nonetheless be important, in interaction with permafrost thaw dynamics, in determining future CH_4 emissions under changing climate.

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