Integrating Metabolomics and Proteomics Reveals Biotic and Abiotic Controls on CO_2 and CH_4 Production in Peatlands

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Project Goals: The objective of the IsoGenie3 Project is to discover how microbial communities mediate the fate of carbon in thawing permafrost landscapes under climate change. We are engaged in a systems approach integrating (a) molecular microbial and viral ecology, (b) molecular organic chemistry and stable and radiocarbon isotopes, and (c) state-of-the-art modeling, across an interconnected system of thawing permafrost and post-glacial lakes in Arctic Sweden.

Arctic peatlands contain a large reservoir of organic C (OC) that may become more available for microbial decomposition upon permafrost thaw and peat warming. Microbial decomposition of peat OC results in the production of CO_2 and CH_4 which may be emitted to the atmosphere, exacerbating climate warming. A decade of radiocarbon dating in non-permafrost and discontinuous permafrost peatlands suggests that CO_2 and CH_4 are produced from dissolved phase OC that is much younger than the solid peat. Even when CO_2 and CH_4 production are observed to increase in response to warming, radiocarbon evidence suggests that peat OC is not mobilized to fuel this increased production. To determine what is fueling the enhanced production in thawing peatlands, we have utilized a suite of complementary environmental metabolomics and proteomics datasets. This approach has highlighted the previously unrecognized importance of abiotic reactions for producing CO_2 in peat. Sterilized incubations revealed the abiotic reaction of N-compounds which can subsequently undergo decarboxylation to produce CO_2, and may also immobilize N through the creation of condensed N-containing rings. Intermediates of biotic reactions, such as de/nitrification, have been shown to participate in similar abiotic transformations suggesting that the biotic and abiotic cycles are intricately linked and may influence CO_2 and CH_4 production in peatlands in complex ways. While abiotic reactions are likely to increase in response to warming (kinetic control), the response of biotic reactions to climate change is complicated by the response of the organisms to warmer temperatures, both their current enzymatic temperature sensitivity and the relative importance of acclimation, adaptation, and assembly processes in changing community-level enzymatic behavior, and therefore may prove more difficult to predict without further characterization of the transformations and interaction with the abiotic cycle.

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