## 55. An Atmospheric $CH_4$ Sink in the High Arctic and its Implication for Global Warming

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Project Goals:

1. Perform ~2 year thawing experiments on well-characterized, intact cores of the Arctic active-layer and permafrost from a proposed reference ecosystem site where $CO_2$ and $CH_4$ fluxes, temperatures, humidity, soil moisture, nutrients, microbial diversity and activities and isotopic analyses are currently being measured.
2. Characterize the vertical flux of volatile organic acids, $O_2$, $H_2$, $CO_2$ and $CH_4$ the isotopic systematics of $CO_2$ and $CH_4$ and changes in the transcriptomics, proteomics and C cycle networks in these cores as the permafrost thaws under water saturated and water under saturated conditions.
3. Compare the fluxes measured for the cores with those measured in the field.
4. Based upon these thawing experiments construct a 1D biogeochemical reaction/transport model that predicts the $CO_2$ and $CH_4$ release into the atmosphere as permafrost thaws and compare these predictions with observations at the reference ecosystem site.

http://www.princeton.edu/southafrica/permafrost-project/

Arctic permafrost underlies about 16% of the Earth's surface and contains ~500 Pg of C down to one meter. Organic-rich peatlands (averaging ~4 wt% SOC) comprise 19% of this area, whereas the remaining 81% is permafrost-affected mineral cryosols (0.5-1.5 wt% SOC). Temperatures in the Arctic are predicted to increase ~6°C over the next 100 years which increases the depth of the active layer, the seasonally thawed soil above the permafrost. Thawing permafrost peat deposits (e.g. Stordalen Mire, Sweden) are currently $CH_4$ sources. Field measurements, intact core studies and microcosm experiments performed by us over the past few years on mineral cryosols associated with ice wedge polygons from Axel Heiberg Island (AHI) in the Canadian high Arctic indicate that they are sinks for atmospheric $CH_4$.

After 1.5 years of thawing at 4°C, 1 m long intact cores of the active layer and underlying permafrost mineral cryosols collected from ice wedge polygons at AHI continue to exhibit uptake of atmospheric $CH_4$ even for water saturated cores. The measured core fluxes are consistent with flux measurements performed in the field over the past two years, which range from 0.005 to 0.89 mg $CH_4$-C/$m^2$-yr and which have revealed significant differences in the atmospheric $CH_4$ consumption fluxes between the polygon interiors and the polygon troughs.

Metagenomic analyses reveal a diverse population dominated by aerobic bacterial heterotrophs (Vishnivetskaya *et al*. 2014) of which ~1% is comprised of methanotrophs (Stackhouse *et al*. 2014). Metagenome and metaproteome analyses of these mineral cryosols have revealed the presence of USC$\alpha$, USC$\gamma$ and Cluster 1 *pmoA* genes, the three genotypic groups that are recognized as high affinity, atmospheric $CH_4$ oxidizers (Lau *et al*. 2014; Martineau *et al*. 2014). Our microcosm studies on atmospheric $CH_4$ uptake rates are consistent with published results from high latitude organic-rich soils

and temperate forest soils and indicate a temperature dependency for the cellular rate of $CH_4$ oxidization that is approximately twice that reported for methanogenesis. This temperature dependency when combined with annual temperature records from nearby Eureka weather station suggests that these high Arctic ice wedge polygons are significant annual sinks for atmospheric $CH_4$. Because the maximum atmospheric $CH_4$ uptake rate coincides with the summer time dips in the recorded atmospheric $CH_4$ and peaks in $\delta^{13}C$, we propose that seasonal variations in the high latitude atmospheric $CH_4$ are partially modulated by the activity of atmospheric $CH_4$ oxidizers. We also propose that this sink will increase with increasing Arctic temperatures and will lessen the interannual increases in atmospheric $CH_4$.

**References**

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