Impact of permafrost extract on CO_2 and CH_4 flux from stream sediments in the Siberian Arctic

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Introduction

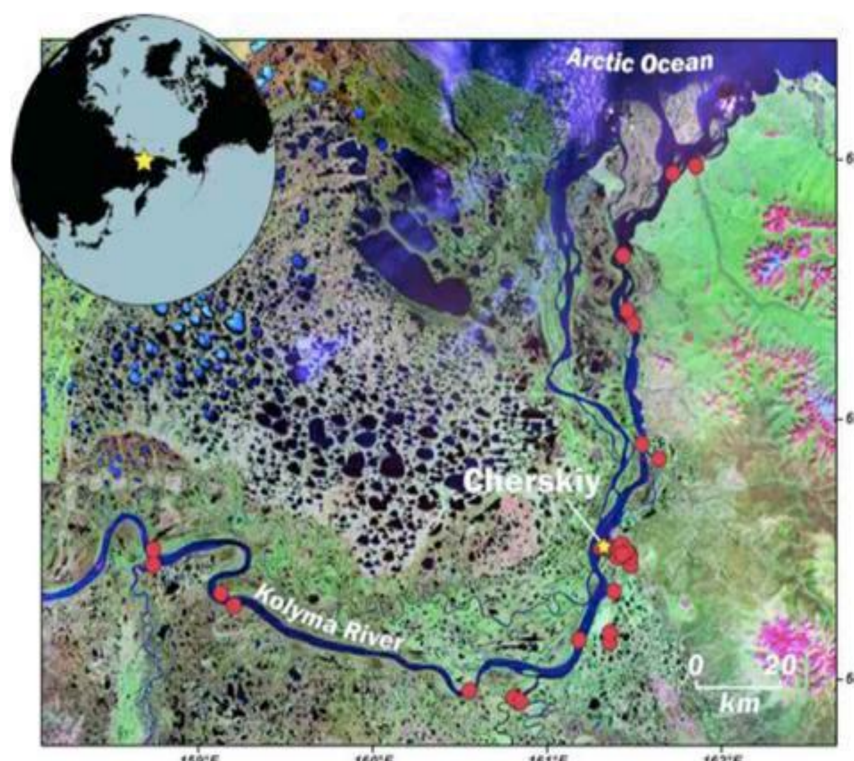


Figure 1- Research was conducted in the Y4 watershed, a small stream in the Kolyma Watershed near Cherskiy. (courtesy of the POLARIS project)

Understanding watersheds as connected landscapes and aquatic systems as potential processors of carbon is essential to understanding how they will change in the future (*Cole et al.*, 2007). Deeper thaw due to Arctic warming may cause previously unprocessed and potentially more bioavailable organic carbon to be released for transport to stream networks (*Vonk et al.* , 2013).

Streams receiving this material may act as avenues for carbon export and/or processors of this material (*Frey et al*., 2009). The role that stream beds play in microbial processing of terrigenous material is poorly understood.

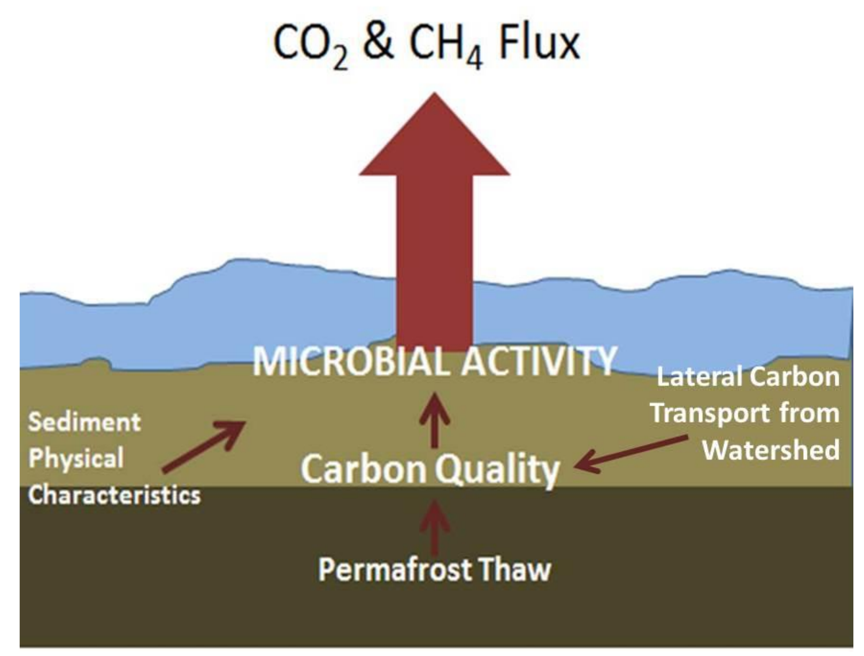


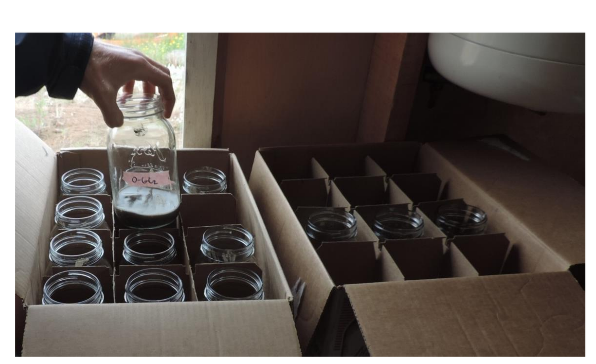
Figure 2- Conceptual model of microbial processing of permafrost-derived carbon in arctic streams

Objectives

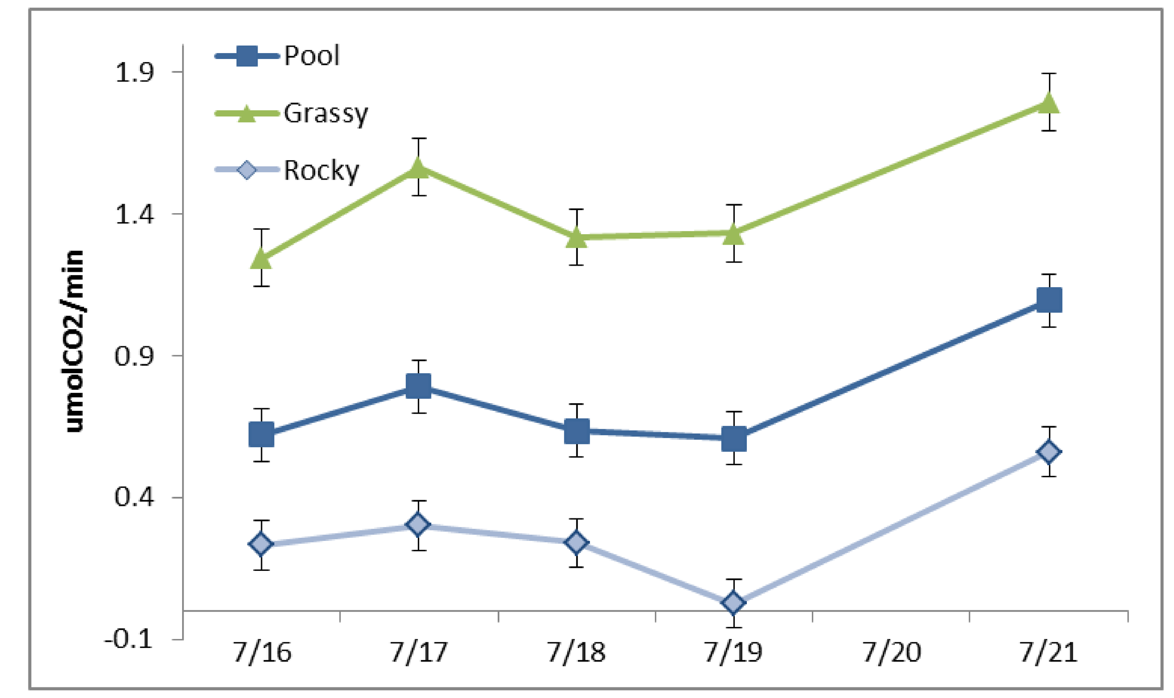
1) **Investigate spatial variation in stream sediment carbon fluxes**
2) **Investigate stream microbial respiration responses to permafrost and active layer carbon additions to simulate potential future changes**

Methods

Stream sediments from Y4 were incubated with leachate from both active layer and permafrost soil and sampled for CO_2 and CH_4 flux.



Data



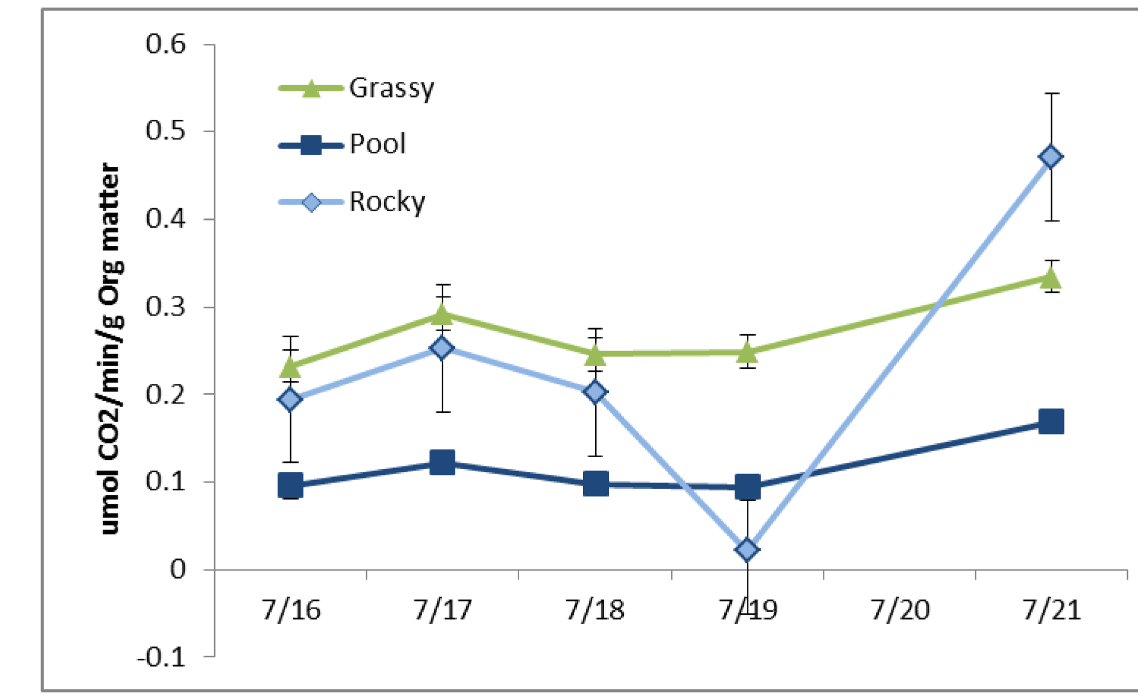


Figure 3- Mean CO_2 flux rates for each sediment source (a) per gram wet mass and (b) per g organic matter. Grassy sediment type remains significantly higher ($p<.001$ for Pool, $p=.05$ for Rocky). Rocky sediment is higher in CO_2 production than pool ($p=0.1$) Since we found no significant effects of treatments, we averaged across treatments.

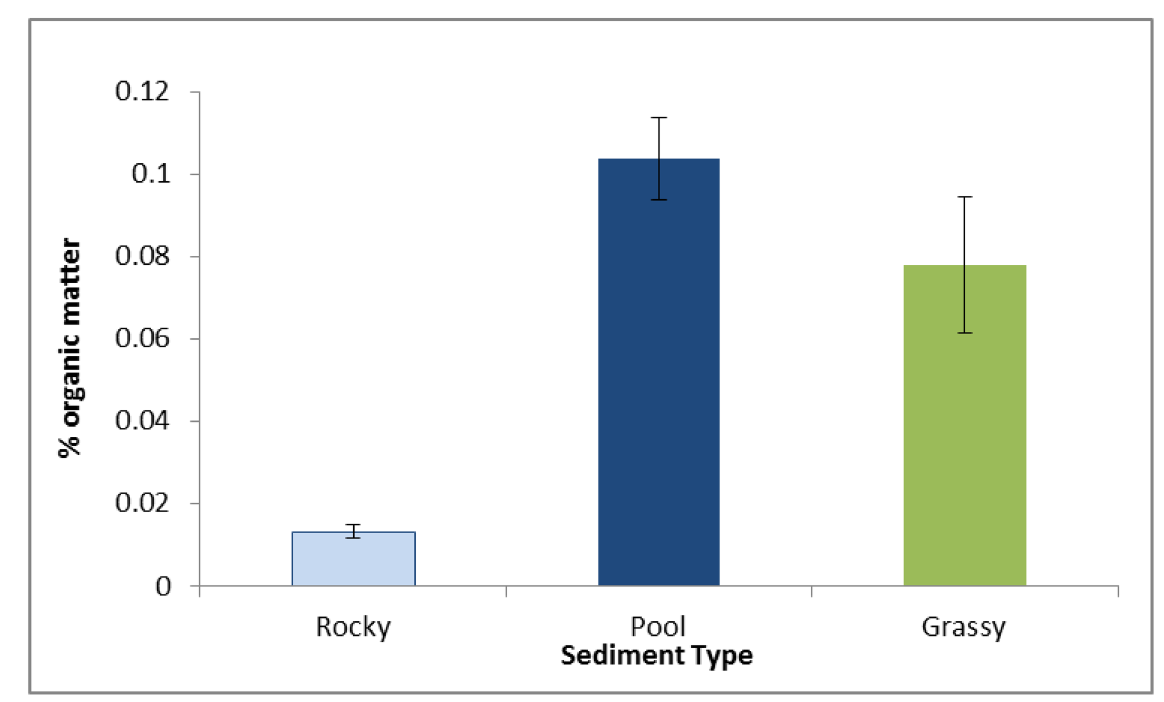


Figure 4- Mean Organic matter content in stream sediments for each location. Rocky sediment has significantly lower organic matter than pool ($p=0.0031$) and grassy sediment ($p=0.015$), however organic matter is similar for pool and grassy ($p=0.31$)

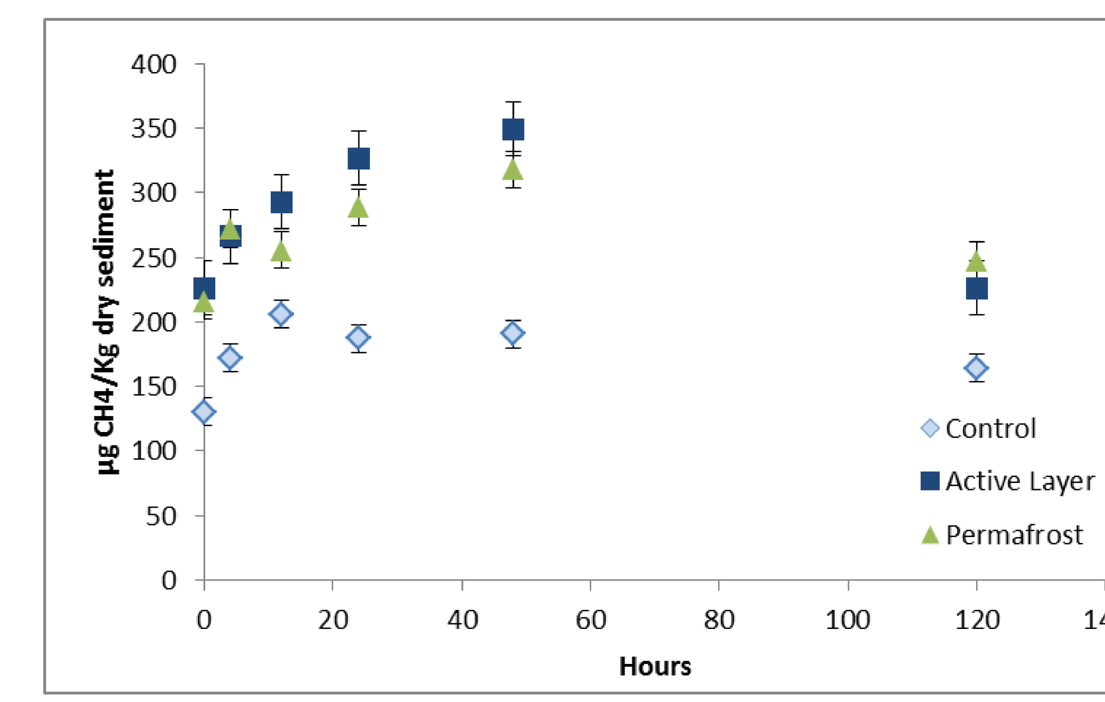


Figure 5- Methane production from grassy sediments. Sediments receiving carbon amendments produced more CH_4, however the differences are statistically insignificant after the full incubation period ($p=0.38$)

Conclusions

- Carbon quality appears to drive differences in carbon flux, illustrated by the difference in CO_2 flux between grassy and pool sediments in spite of a lack of a significant difference in organic matter content.
- Preliminary data illustrate that labile carbon drives methane production and carbon availability is limiting, suggesting that increased available carbon from permafrost thaw may lead to an increase in CH_4 production in arctic streams.
- As the arctic warms, a shift from CO_2 to CH_4 production in stream sediments may act as a positive feedback to climate change. This is particularly important as it suggests the fate of carbon released from permafrost thaw depends upon where the carbon is processed.

Literature Cited

Cole et al. 2007. Plumbing the Global Carbon Cycle: Integrating Inland Waters into the Terrestrial Carbon Budget. Ecosystems 10, 171-184.
Frey and McClelland. 2009. Impacts of permafrost degradation on arctic river biogeochemistry. Hydrological Processes 23, 169-182.
Vonk et al. 2013. High biolability of ancient permafrost carbon upon thaw. GRL doi: 10.1002/grl.50348.