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Source characterization and temporal variation of methane seepage from thermokarst lakes on the Alaska North Slope in response to Arctic climate change

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Summary

The goals of this research are to characterize the source, magnitude and temporal variability of methane seepage from two representative thermokarst lake areas within the Alaskan North Slope gas hydrate province, assess the vulnerability of these areas to ongoing and future Arctic climate change and determine if gas hydrate dissociation resulting from permafrost melting is contributing to the current lake emissions. Work during this quarter has focused on continuing the group laboratory analyses on samples and data collected from the Year 1 and 2 fieldwork. Analyses have focused on four main lake locations refered to in this report: Lake Qalluuraq (referred to as Lake Q) and Lake Teshekpuk (both on Alaska's North Slope) and Lake Killarney and Goldstream Bill Lake (both in Alaska's interior).

Biogeochemisry (Pohlman and Wooller - USGS): Ion chromatographic analysis of major cations, major anions, dissolved inorganic nitrogen species from the May and July lake waters were conducted by Pohlman. Cation and anion data were used to identify water sources emanating from the seep at Lake Q and to calculate the fraction of lake water that was sequestered by ice during ice covered conditions. Dissolved organic carbon concentration, carbon isotope analysis and fluorescence analysis from the May lake water samples were also conducted by Pohlman to quantify the emission of permafrost derived carbon from the main seep in Lake Q. Wooller and Pohlman have been in correspondence with Kelly Rose and Corinne Disenhof to discuss their results from XRD analyses of sediment cores taken from Lake Q. The data are complete on these cores.

Task 5.0 and 6.0 - Measuring methane flux on multiple temporal scales. Katey Walter Anthony (UAF): Walter Anthony supervised a variety of activities during the past quarter. She hosted visiting scientists and collaborators on this project, Dr. Frederic Thalasso and Ph.D. student, Armando Sepúlveda Jáuregui, from Cinvestav University in Mexico City. Thalasso and Jáuregui arrived at UAF in September 2010. The purpose of their work at UAF is to conduct laboratory incubations to assess CH4 oxidation and CH4 production potentials of thermokarst lakes. Their work is complimentary to that of Co-PI Leigh's lab studies, and the ultimate goal is to bring the full suite of results together for a more comprehensive understanding of CH4 cycling in the interior Alaska thermokarst lakes. In line with these goals, Walter Anthony organized two project meetings at UAF to bring institutional investigators together for the purpose of summarizing activities to date discussing remaining goals on the project and strategies for integrating field observations and laboratory activity among all the investigators. Meetings were in April and October 2010. Walter Anthony's group has nearly completed the long-term flux trap data collection on sixteen seeps at Goldstream Lake. The flux data were combined with a parallel data set collected previously on Siberian lakes and resulted in a publication on the methods of assessing ebullitions seep fluxes in lakes: Walter Anthony, K. Vas, D., Brosius, L., Chapin, F. S. III, Zimov, S.A., and Zhuang, Q. 2010. Estimating methane emissions from northern lakes using ice bubble surveys. *Limnol. Oceanogr.: Methods* 8, 2010, 592–609. Numerous traps are still frozen in the lake ice on Goldstream Lake. Final data will be downloaded in the spring and analyzed for the final project report. In order to better assess the whole-lake CH4 cycling, Walter Anthony's group has been monitoring dissolved gas profiles in Killarney and Goldstream lakes throughout winter. They are also making regular measurements of the physical and chemical limnology of these lakes. Walter Anthony's group is working on a mesocosm experiment to

study CH4 oxidation in situ in Goldstream and Killarney Lakes. We are working out remaining glitches in methodology, and are hopeful to run the first full short-term incubation in the lakes during the next two weeks. Finally, Walter Anthony has worked on compilation of a large data set on geologic CH4 seeps across the state of Alaska. Some of the key data were collected through this project, but significant portions of the study were funded through other federal grants and internal funds of the Co-PI. Walter Anthony is in the process of analyzing geospatial and isotope data, and anticipates at least one peer-review publication to come from this work that would involve other project PIs as co-authors.

Task 7.0 - Methane oxidation in Alaskan thermokarst lakes. Mary Beth Leigh (UAF) and Ruo He (UAF): Stable isotope probing (SIP) studies have been conducted to identify active methane utilizing bacteria in sediments from a range of depths from several sampling sites from our study lakes. Following incubation with $^{13}CH_4$, DNA was extracted from the sediment SIP samples and was subjected to isopycnic centrifugation and fractionation using established methods. ^{13}C-DNA-containing fractions were subjected to PCR to amplify bacterial 16S rRNA genes, as well as Type I and Type II methanotrophs and methane oxidation genes. Bacteria and functional genes were characterized and phylogenetically identified from ^{13}C-DNA amplicons by terminal restriction fragment length polymorphism (T-RFLP), cloning, Sanger sequencing and high throughput pyrosequencing analysis. Raw clone sequences of Type I, Type II methanotrophs and 16S rRNA genes were processed by using pipeline quality filter tools on the Ribosomal Database project website (http://rdp.cme.msu.edu/pipeline) and tested for chimeric sequences using Mallard 1.02 software. Pyrosequencing was performed using Roche 454 GS FLX Titanium sequencing (454 Life Sciences, Branford, CT, USA) at the Research Technology Support Facility, Michigan State University (East Lansing, MI USA). Sequences were first trimmed of the primer region and low-quality sequences were removed. The sequences that passed this filter were taxonomically assigned by the Ribosomal Database Project's (http:// rdp.cme.msu.edu) Naïve Bayesian Classifier (80% confidence threshold). Sequences were dereplicated with the CAP3 program with 97% sequence identity cutoff to separate the sequences into groups of related sequences known as operational taxonomic units (OTUs). Phylogenetic trees were constructed with one representative sequence from each OTU cluster along with reference sequences of the nearest matching sequences from GenBank.

Task 8.0 - Establishing a long-term record of the variability in methane emissions in relation arctic climate change. Matthew Wooller (UAF) and Pohlman (USGS): Gaglioti continues to prepare samples from the year 2 field work conducted at Teshekpuk. Samples from the Teshekpuk core were submitted to NOSAMS for dating and the results show that the lacustrine portion of the lake is likely ~13,500 year old. Bulk stable carbon and nitrogen isotope analyses have been conducted and indicate that the lacustrine portion of the core seems to overlay more terrestrial/sandy sediment. Further analyses of the core are now underway. Pohlman and his collaborators in Germany conducted deuterium analysis of n-alkanes and hopenes to infer hydroclimatic shifts on the North Slope during the Holocene. Various temperature proxies of Lake Q and the atmosphere during the Holocene were determined. These data were interpreted for the following abstract, submitted for an oral presentation at the International Meeting of Organic Geochemistry (IMOG): Carbon and hydrogen isotope biomarker records of methane release and hydroclimatic variability from a thermokarst lake in the Alaskan Arctic.

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