Oil & Natural Gas Technology

DOE Award No.: DE-NT0005665

Quarterly Progress Report (October - December 2011)

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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Prepared for:
United States Department of Energy
National Energy Technology Laboratory

February 27, 2012

Office of Fossil Energy

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CONTRACT NO. NT0005665

QUARTERLY PROGRESS REPORT
Reporting Period: Oct 1 - Dec 31, 2011

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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 Alaska 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 preparing presentations of the results related to all of the projects Tasks. The next quarter will also be dedicated to publishing the primary data from this project. Once the bulk of this primary data is published (efforts and scope described below) the group will focus on synthesizing the results from the separate tasks. This synthesis effort will subsequently address the final milestone related to the project to "Integrate laboratory results and complete a comprehensive analysis of methane seepage in thermokarst lake settings". With many of the papers documenting the primary data from the project nearing completion the group's efforts in the next quarter can be turned towards this final milestone. Analyses have focused on four main lake locations referred 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). Additional sites (Burial Lake and Quartz Lake) have been added by Wooller to supplement Task 8. Analyses of samples from Year 1 fieldwork are virtually complete and data from this fieldwork and sites are being included in a range of papers and presentations (see below). Analyses of samples collected from Year 2 fieldwork at Lake Teshekpuk are being completed and will likely be complete during the next quarter.

Tasks 1 - 4 and 6: These tasks relate to field activities and have been completed and reported in previous quarterly reports.

Task 5.0 – Quantifying the short-term variability in methane emissions. Katey Walter Anthony:

During the past quarter, we have worked on data analysis for methane emissions from the Fairbanks thermokarst lake study site (Goldstream Lake). Data include ebullition fluxes, diffusive emissions, storage release, and atmospheric methane concentrations measured with a LiCor 7700. These data are being processed for a manuscript on the seasonality of methane releases from an interior Alaska thermokarst lake. In addition, we continue to collect monthly data on dissolved gas concentrations in the lake, ice and snow thickness, water level (hydrostatic pressure).

Task 7.0 - Methane oxidation in Alaskan thermokarst lakes. Mary Beth Leigh (UAF), Ruo He (UAF), Pohlman (USGS):

Stable isotope probing experiments aimed at identifying methane-oxidizing microbes and functional genes in lake sediments and water have been completed. Data analyses have been completed and manuscript preparation, submission and revision are actively underway. Five manuscripts have been drafted in full. Of these, two manuscript has been accepted, one additional manuscript has been submitted, and two others are in the final stages of preparation for submission. The title and current status of each manuscript is listed below.

Manuscripts accepted

He, R. M. J. Wooller, J. W. Pohlman, C. Catranis, J. Quensen, J. M. Tiedje, **M. B. Leigh.** Identification of functionally active aerobic methanotrophs in sediments from an arctic lake using stable isotope probing. *Environmental Microbiology.* Accepted Feb., 2012.

He, R. M. J. Wooller, J. W. Pohlman, J. Quensen, J. M. Tiedje, **M. B. Leigh**. Diversity of active aerobic methanotrophs along depth profiles of arctic and subarctic lake water column and sediments. *The ISME Journal*. Accepted Feb., 2012

Manuscript submitted

He, R. M. J. Wooller, J. W. Pohlman, J. Quensen, J. M. Tiedje, **M. B. Leigh**. Shifts in identity and activity of methanotrophs in arctic lake sediments in response to temperature changes. Submitted to Applied and Environmental Microbiology. *Submitted Oct., 2011. Resubmission of revision invited. Re-submission planned for Feb., 2012.*

Manuscripts in preparation

He, R. M. J. Wooller, J. W. Pohlman, J. Quensen, J. M. Tiedje, **M. B. Leigh**. Methane-derived carbon flows in microbial community in arctic lake sediments assessed by stable isotope probing of DNA and phospholipid fatty acids. *Manuscript in preparation.*

He, R. M. J. Wooller, J. W. Pohlman, J. Quensen, J. M. Tiedje, **M. B. Leigh**. Anaerobic methane oxidizers active in an arctic lake methane seep. *Manuscript in preparation.*

Dissolved methane concentrations from sediment cores collected at Lake Teshekpuk (453 cm long), Lake Helen (512 cm long), Lake Kogru (72.5 cm long) and Lake 21 (67.5 cm long) were analyzed by gas chromatograph-flame ionization detection. A total of 127 samples collected at a vertical sampling resolution of 5-15 cm were analyzed. From Lake Teshekpuk, 44 samples were obtained with the Livingston piston corer and Bolivia gravity corer. From Lake Helen, 44 samples were obtained with the Livingston piston corer and Bolivia gravity corer. From Lake Kogru, 25 samples were collected from the Bolivia gravity corer. And from Lake 21, 14 samples were collected with the Bolivia gravity corer. Concentration profiles from the Lakes Helen and Teshekpuk increased with greater depth the base of organic rich Holocene sediment and then decreased slightly in the deeper sandy sections. Lake 21 methane concentrations were high throughout, and the Lake Kogru concentrations were low throughout.

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):
The analyses of Lake Q are complete and a manuscript describing the results was prepared and submitted on Aug 31st 2011 to a special issue of the Journal of Paleolimnology (JoPL). The manuscript is now fully accepted for publication and proofs are being generated. This paper includes biomarker data generated by German collaborators with Pohlman and our project. This JoPL special issue is dedicated to climate change records from arctic lakes. The technologies

developed and applied to analyze the Lake Q west core were also applied to two other long cores accessed by Wooller et al. (one from the Brooks range [Burial Lake] and covering the period ~25,000 years to present) and one from the discontinuous permafrost region in the interior of Alaska (Quartz Lake, ~12,000 year to present). A manuscript documenting results from Quartz Lake is complete and has also been accepted for publication documenting the chronology of the core along with a suite of proxies of the past environmental conditions at the site. Although this paper's emphasis is the past hydrology of the site the analyses of proxies of past methane have been completed from the core and provide a record of over 11,000 years. A full manuscript is complete from Burial Lake and is still being circulated amongst the co-authors for comments. Completion of the Burial Lake paper was expected within the last quarter but will be undergoing further modifications to accommodate comments from the co-authors in the next quarter. A manuscript focused on biomarker data from Lake Q has been initiated.

Matthew J. Wooller, et al. (in press) A ~12,000 year record of the variability in methane emissions from an arctic wetland related to climate change. Journal of Paleolimnology.

Matthew J. Wooller et al. (in press) 11,000 years of climate and limnological change from Quartz Lake, Alaska. Journal of Paleolimnology.

Matthew J. Wooller et al. (in preparation) A record of Late Quaternary climate change in the northwestern Brooks Range, Alaska

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