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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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QUARTERLY PROGRESS REPORT
Reporting Period: Jan. 1- Mar. 31, 2009

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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 and to assess the vulnerability of these areas to ongoing and future Arctic climate change.

Work during the second quarter of this project has focused on finalizing the group's first field work in the spring of 2009 (May 2009). The majority of the project's future tasks are contingent on the acquisition of samples to analyze from the proposed field locations. These future tasks will be initiated once samples have been collected from the proposed field sites. The group had a WEBEX project meeting (March 27 2009) to finalize the details for field-work and have presented the concepts and preliminary findings associated with the proposed research (see list of presentations below).

Activities in This Reporting Period

Task 2.0 - Continuous Literature Research and Updating

The Recipient has established a pdf reference library of related and relevant literature using the program "Papers" (see http://mekentosj.com/papers/). 'Papers' synthesizes technologies to give a complete new workflow for reading scientific articles. Articles can be downloaded, archived, and organized within a single application. This program is also compatible with the program 'Endnote' that amongst other resources allows comprehensive reference lists to be drafted. A list of references is available on request. The USGS is continuing to compile hard-to-obtain North Slope reports from its own national libraries and working on the transfer of a North Slope gas chemistry database from the Central/Western Regions to the Woods Hole office.

Task 3.0 – Develop Data Collection and Sampling Plan

The UAF/USGS team has developed a data collection and sampling plan to cover field activities occurring in year 1. The final plan will submitted 20 days prior to the field work (commencing May 7th 2009). Detailed discussions have already taken place between the PIs (notably Wooller, Pohlman and Leigh) to develop an optimal coring plan that will accommodate all of the analyses to be conducted on the cores (i.e. paleo isotope analyses, biomarker analyses, and stable isotope probing respectively).

Status summary of other project related activities that have taken place during the last quarter:

1) Project meeting: A project meeting to discuss field-work logistics took place via WEBEX hosted by USGS and Pohlman on the 27th March, 2009 and was attended by Matthew Wooller (UAF PI), John Pohlman (USGS Co-PI), Mary Beth Leigh (UAF Co-PI), Ben Gaglioti (UAF Graduate Student Research Assistant), Katey Walter (UAF Co-PI) , Robert Vagnettii (NETL Project Manager) and Monica Heintz(UCSB graduate student). Discussions focused on developing a field sampling plan (notably focused on coring lake sediments).

2) Preparations for Task 11.0: Methane oxidation in Alaskan thermokarst lakes. A full UAF

job search through human resources for a post-doctoral research associate was completed in Nov. 2008. The aim was to establish the post-doc ready to take part in the collection of samples during the May field-work. Four qualified applicants were considered and references were contacted. An offer of a post-doctoral research associate position was made and accepted by Dr. Ruo He. Dr. He's visa and UAF paper work is completed and she is expected to be in Fairbanks on the 28th April 2009, ready to embark on the May 2009 field work with the group. Dr. He will bring valuable experience in analyzing the microbial communities associated with methanotrophy in our lake systems.

3) Preparations for Task 4.0 – Field-work in Alaska (Year 1) (See details below).
4) A project website has been established documenting a pilot field study related to research at Qalluuraq Lake: (http://www.uaf.edu/water/ASIF/Methane%20ecology/Front%20page.html). The website was updated in March 2009 with examples of equipment testing in the local Fairbanks area: (http://www.uaf.edu/water/ASIF/Methane%20ecology/Field%20work%2009.html).

Milestones log - indicate status of milestones.

Preparations are continuing for the group's first field-work (May 2009: Qalluuraq Lake seep and Kilarney Lake). Field equipment, which includes coring and seismic imaging equipment, is being organized. Dates are agreed for spring 2009 field-work (5 to the 6th May = Fairbanks field-work and testing equipment. 7th May = Travel Fairbanks to Lake Qalluuraq. 8th to the 13th May Lake Qalluuraq field-work. 14th May, Travel back to Fairbanks. 15th Archive and pack samples ready for further analyses). Geophysical imaging and further biogeochemical sampling will take place during July 2009. Dates for this second round of field-work have been established (7th – 14th July) and have resulted from e mail discussions between the group, which including Kelly Rose.

Issues - summary of any issues that may impact schedule/cost

NEPA forms have been submitted to DOE-NETL.

Planned Publications/conference presentations upcoming.

1) Deines P., **Wooller M.J.** & Grey J. (2009 in press): Unraveling complexities in benthic food webs using a dual stable isotope (hydrogen and carbon) approach. Freshwater Biology.

2) **Wooller M.J.** (2009 – invited talk): Establishing records of past methane emissions in arctic Alaska. Utrecht, The Netherlands. Invited Seminar April 9 – 17th 2009

3) **Wooller M.J.,** Gaglioti, B. and **Walter K.** (2009: abstract submitted): Paleo methane emissions in arctic Alaska. Arctic Workshop, Maine.

STABLE ISOTOPE ANALYSES OF FOSSIL CHIRONOMIDS AS A NEW APPROACH FOR INVESTIGATING LATE-QUATERNARY METHANE EMISSIONS FROM LAKES IN BERINGIA

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Some thermokarst lakes in areas that compose Beringia are currently making a significant contribution to the global atmospheric methane budget. In some instances methane emitted results from the degradation of organic matter originally formed during the Late Quaternary. Unfortunately, there is a distinct lack of information concerning the relationship between the long-term record of methane emissions from thermokarst lake ecosystems and Beringian climate change. The instrumental record of past methane emissions is short, and longer-term records (thousands of years) of methane production generally relate to the global atmosphere, not the temporal variability of methane production from specific lake sites in the Arctic during the Quaternary. Paleoecological approaches are needed to establish long-term records (greater than the instrumental record) of the past environment to potentially observe the causes and degree of former methane emission from thermokarst lakes. One of the most common ways to examine past environmental changes is to examine materials (both sub-fossils and chemical signatures) preserved in dated sediment cores taken from lakes. We removed a ~2 m core of lake sediment from Qalluuraq Lake (south of Barrow, Alaska), which has an area of the lake that is vigorously emitting methane, bubbling to the surface of the lake (3,000-5,000 ft^3 day^{-1}). A preliminary basal sample from our sediment core was submitted for AMS radiocarbon dating and resulted in a calibrated age of 11,500 ($\pm$ 180) calendar years before present. Stable carbon isotope values produced from analyses of modern (live) chironomid (aquatic insects) larvae from Qalluuraq Lake were as low as -40.5 per mil. These values are considerably lower than the stable carbon isotope values of the total organic carbon content of the recent sediments ($\geq$ -30 per mil) and are consistent with the chironomids currently consuming biomass (originally microbial) derived from methane oxidation. A radiocarbon analysis of these 'modern' chironomid larvae also produced a ^{14}C 'age' of 1760 years, which supports the role of 'old' methane in the diet of these modern benthic invertebrates. These data indicate that the fossil chironomid remains that are abundantly preserved in the sediment should not be used for radiocarbon analyses to date our core. However, they illustrate that they could be used as a bio-indicator of past consumption of biomass derived from methane oxidation and therein episodes of past methane emission from the lake. We present stable isotope analyses of fossil remains in our sediment core to provide a paleoenvironmental reconstruction of this methane-emitting site in Eastern Beringia.

5) **Wooller, M.J.** (2008): Source characterization and temporal variation of methane seepage from thermokarst lakes on the Alaska North Slope in response to Arctic climate change, Field work plan, sampling for May 2009. WEBEX presentation. March 27th 2009.

6) Heiri, O, **Wooller, M.J.**, van Hardenbroek, M. and Wang, Y. (in press), Recent Advances in

Paleolimnology: Stable isotopes in chitinous fossils of aquatic invertebrates. Special issue PAGES newsletter.

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