USING OPEN-PATH LASER MEASUREMENT OF ATMOSPHERIC METHANE CONCENTRATION ALONG A MAJOR SHEAR ZONE IN WESTERN GREENLAND AS AN ANALOGUE FOR EXPLORATION ON MARS.

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Introduction: Understanding biotic and abiotic cycling of methane (CH_4) on Earth is critical for improved understanding of Earth's climate system. CH_4 is a strong greenhouse gas, contributing about twenty times more strongly, per molecule, than carbon dioxide to the greenhouse effect [1]. Surprisingly, inputs of atmospheric CH_4 from arctic permafrost are poorly constrained [2]. Microbial methanogenesis (production) and methanotrophy (consumption) can be complexly interwoven with abiotic cycling near sites where mafic rock units are actively weathering by exposure to surface or ground water. Monitoring seasonal changes in CH_4 cycling along shear zones and rift valleys that intersect deep permafrost on Earth is a key step in assessing plausible origins and fates of methane on Mars [3].

Methods: In August of 2011, we deployed a Boreal Open-Path Laser along a major shear zone extending for tens of kilometers from the margin of the ice sheet to the head of Sondre Stromfjord near Kangerlussuaq, Greenland. Bedrock in this area consists of Archaean gneisses with numerous cross-cutting mafic dykes. One principal sinistral strike-slip fault and numerous ancillary faults are visible in satellite images of the linear valley that defines our study site.

The infrared laser was positioned at a height of 0.5 to 2.0 meters above the ground surface and was run for durations of 1.0 to 4.5 hours along nine transects across the shear-zone valley. The transect length varied from 22.6 to 77.0 meters, reflecting the distance between the steep valley walls. Raw data was transformed by removing readings of 0 ppm, removing data taken before a stable light level was obtained, and narrowly defining the range of light levels for optimal performance.

Results and Discussion: The average concentration of CH_4 measured across the shear-zone valley varied from 1.4- 2.3 $\pm$ 0.1 ppm (Fig. 1). Substantial variation in concentration is inferred to result from the presence of open-water lakes and vegetated wetlands for high values and rocky outcrops for low values. Background concentrations of atmospheric CH_4 from ice-margin environments in Greenland are about 1.8 ppm [4]. Previous studies of methanogenic arctic environments have reported atmospheric CH_4 concentrations of 1.7-2.3 ppm [2]. Data obtained in 2011 by open-path laser measurements suggest that the studied shear-zone in western Greenland is a significant net emitter of CH_4 in late summer.

Implications for Mars: An open-path laser system for measuring CH_4 concentrations on Mars could be a valuable addition to future landed Martian missions. Depending on topography at the landing site, a roving laser could be aimed at a mirror mounted on the landing platform or dropped along the traverse path. If mean atmospheric methane concentrations on Mars are seasonally as high as 30 ppb [3] then open-path laser measurement could be a highly effective method for assessing CH_4 emissions from landscapes features such as lineaments, depressions, or mounds. Given atmospheric pressure in the range of 0.001 to 0.010 bar [5] [6], deployment of an open- path laser system on the Martian surface will need extensive testing for accuracy at low millibar pressures. Operating an open-path laser system over distances of hundreds to thousands of meters will improve sensitivity by increasing the number of CH_4 molecules interacting with the laser along the line-of-sight path.

Future Studies: Future studies in western Greenland will allow determination of diurnal and seasonal fluxes of CH_4 allowing for comparison with fluxes at other permafrost sites in the northern and southern hemispheres. Starting in summer of 2012, a suite of field instruments will allow *in situ* determination of carbon and hydrogen isotopic compositions for CH_4 sampled in soil-pipe wells and in bedrock boreholes. The combination of concentration and isotopic signatures for CH_4 will help unravel biotic from abiotic influences on methane cycling along a major shear intersection of a deep permafrost profile in western Greenland.

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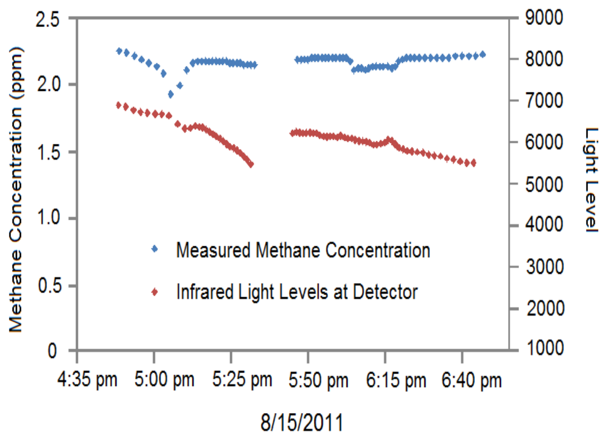

Fig. 1. Refined data is shown for cross-valley detection of CH_4 concentration along a shear zone in western Greenland. Mean measured CH_4 concentration at this site 2.2 $\pm$ 0.1 ppm with light levels for optimum performance restricted to values between 5500- 7500.