Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.4998

Methane Production Controls in Thermokarst Lake Sediments

DR. ANDRE PELLERIN[1], NOAM LOTEM[1], EFRAT ELIANI RUSSAK[1], NICHOLAS HASSON[2], KATEY WALTER-ANTHONY[2] AND ORIT SIVAN[1]

[1]Ben Gurion University of the Negev
[2]Unviersity of Alaska Fairbanks

Presenting Author: andrepellerin@gmail.com

Methane (CH_4) release to the atmosphere from thawing permafrost contributes increasingly to global CH_4 emissions and exacerbates anthropogenic warming. In thawing permafrost, it is local redox conditions, the availability of electron acceptors, and the nature of the substrate under degradation that controls the microbial communities consuming organic matter and producing CH_4. However, the short and long-term impacts of these different variables on the fate of organic matter in the Arctic and the global CH_4 emissions are still unclear. The relationship between metabolic pathways responsible for organic matter degradation to CH_4 and its relationship with the CH_4 production rate were investigated in a young thermokarst lake in central Alaska.

Tracer incubations with labeled 2-^{14}C acetate and ^{14}C CO_2 indicates that the pathway of CH_4 formation shifts from CO_2 reduction-dominated in lithological layers of redeposited loess, to acetate disproportionation-dominated in layers of organic-rich peat. This shows that the pathway of CH4 formation is highly dependent on lithology. However, only small variations in CH4 production rates are observed between different lithological units. This indicates a relatively constant CH_4 production rate despite different sedimentary depositional contexts. Therefore, regardless of the pathway involved, the net CH_4 production appears disconnected from lithology.

$\delta^{13}C$ and ^{14}C measurements of CH_4 and organic matter show that ~50% of CH_4 dissolved in the porewater is produced below the first meter of the talik, indicating that deep CH_4 production is significant to overall CH_4 emissions. Integrating the CH_4 production measurements down to the permafrost depth suggests that the predicted CH_4 fluxes align with measurements of hotspot emissions and are only twofold higher than average CH_4 emissions from the studied lake or other high-CH_4-emitting thermokarst lakes.

These findings demonstrate that CH_4 production rates and their integration over thaw depth gives a similar magnitude to CH_4 emission estimates from water-saturated environments with deep thawing taliks. This indicates that in some situations, net CH_4 emissions could be extrapolated from CH_4 production measurements with only a few assumptions concerning lithology. The power and limitations of these assumptions will be discussed and expanded.