Microbial Community Drivers of Porewater Methane Concentrations in Arctic Peatland Thaw Ponds

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Introduction

- Permafrost is soil that has been frozen for two or more years consecutively, limiting organic matter decomposition[1].
- When permafrost thaws, ponds can form due to the depression of ice-rich ground[2].
- These ponds are hotspots for methane production[3] due to anaerobic conditions and high organic matter content.
- The organic matter is made available for decomposition by methanogens, leading to release of methane (CH_4), a more potent greenhouse gas than CO_2[4].

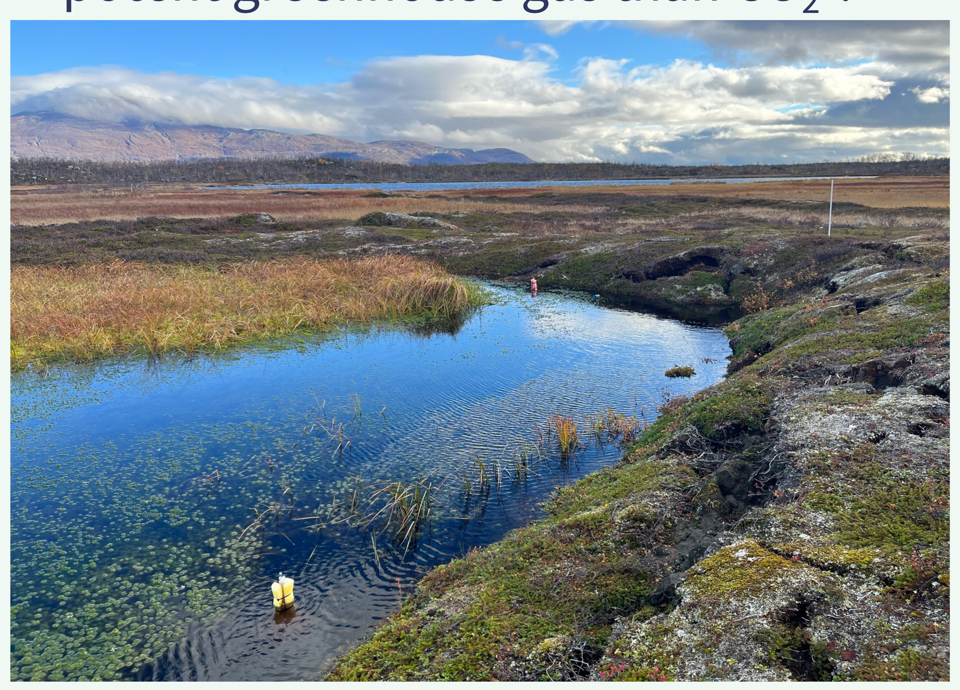
Figure 1: Stordalen Mire, Sweden[4]

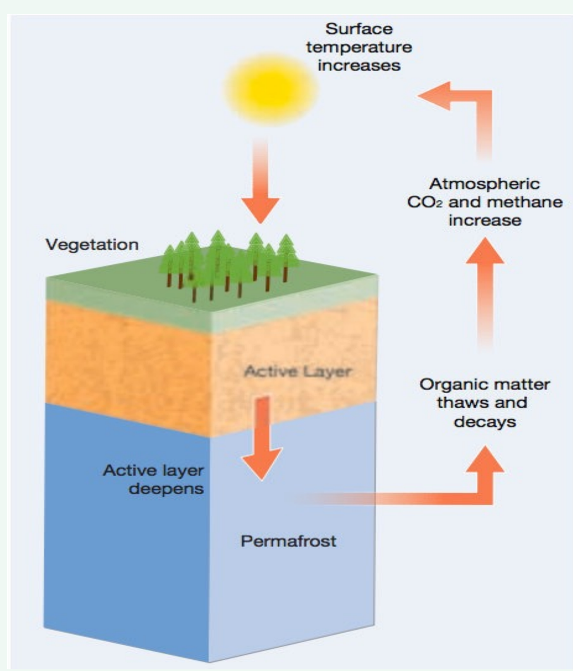

Figure 2: Methane cycling in permafrost[5]

Overarching question: How do variations in the relative abundance of significant methanogens correlate with the net fluxes of CH_4 observed across different depths in Arctic-boreal ponds experiencing permafrost thaw?

Methods

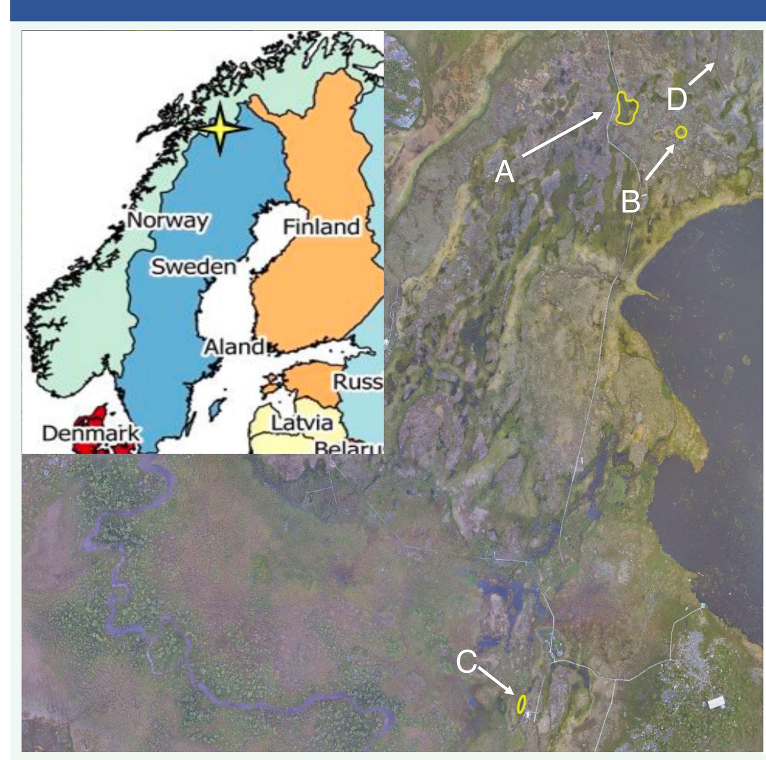

Figure 3: Sites of sample collection[6]

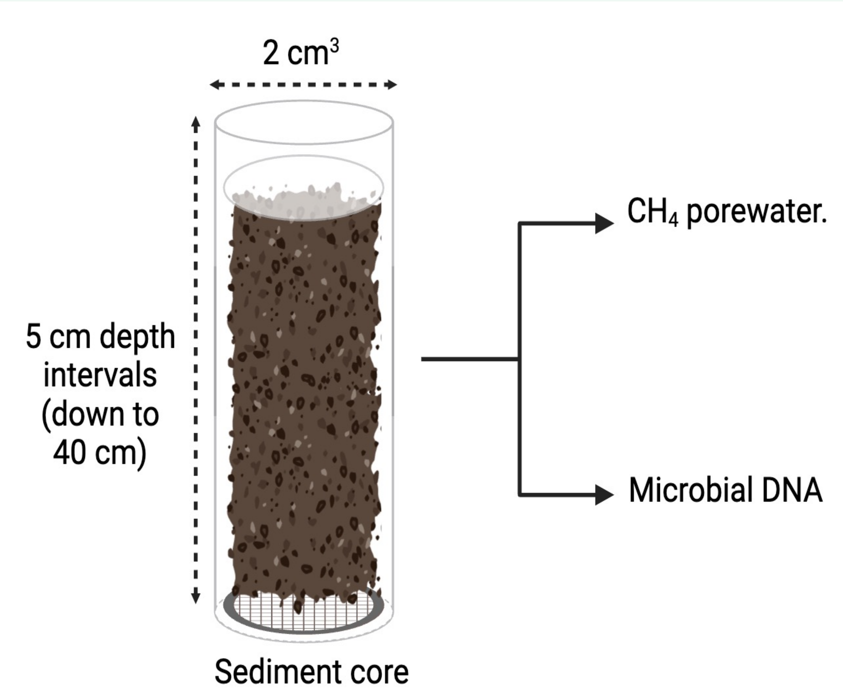

Figure 4: Figurative methodology

- Replicate (3x) sediment cores collected from two different types of ponds (shallow and deep) at Stordalen Mire, Sweden.
- CH_4 concentrations were measured from porewater.
- Bacterial DNA was extracted from the sediment and sequenced to quantify the relative abundance of methanogens.

Results and Discussion

There was no observed relationship between depth and the methanogen relative abundance

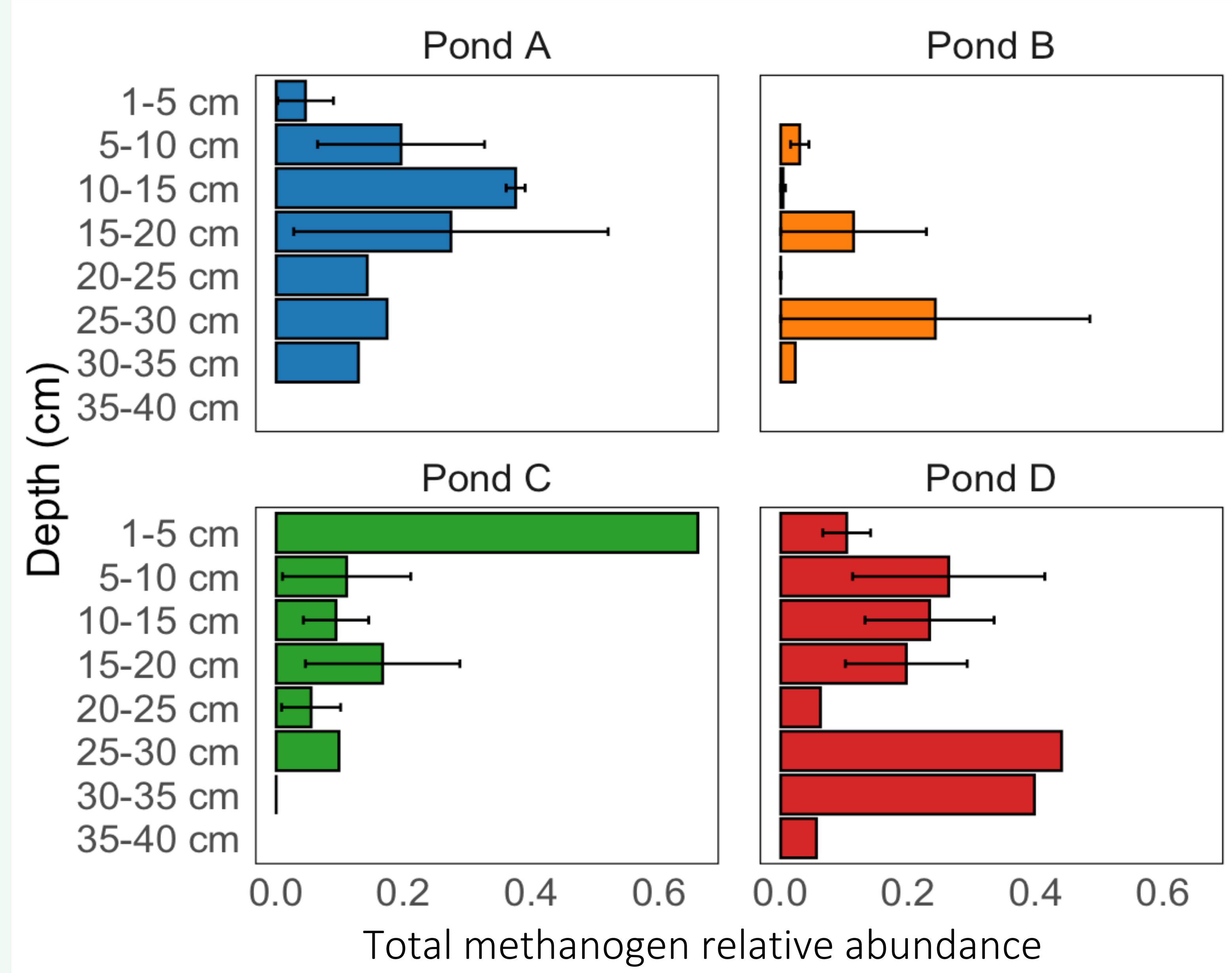

Figure 5: Depth (cm) and the percent relative abundance of methanogens

There was a quadratic relationship observed between depth and the CH_4 concentration

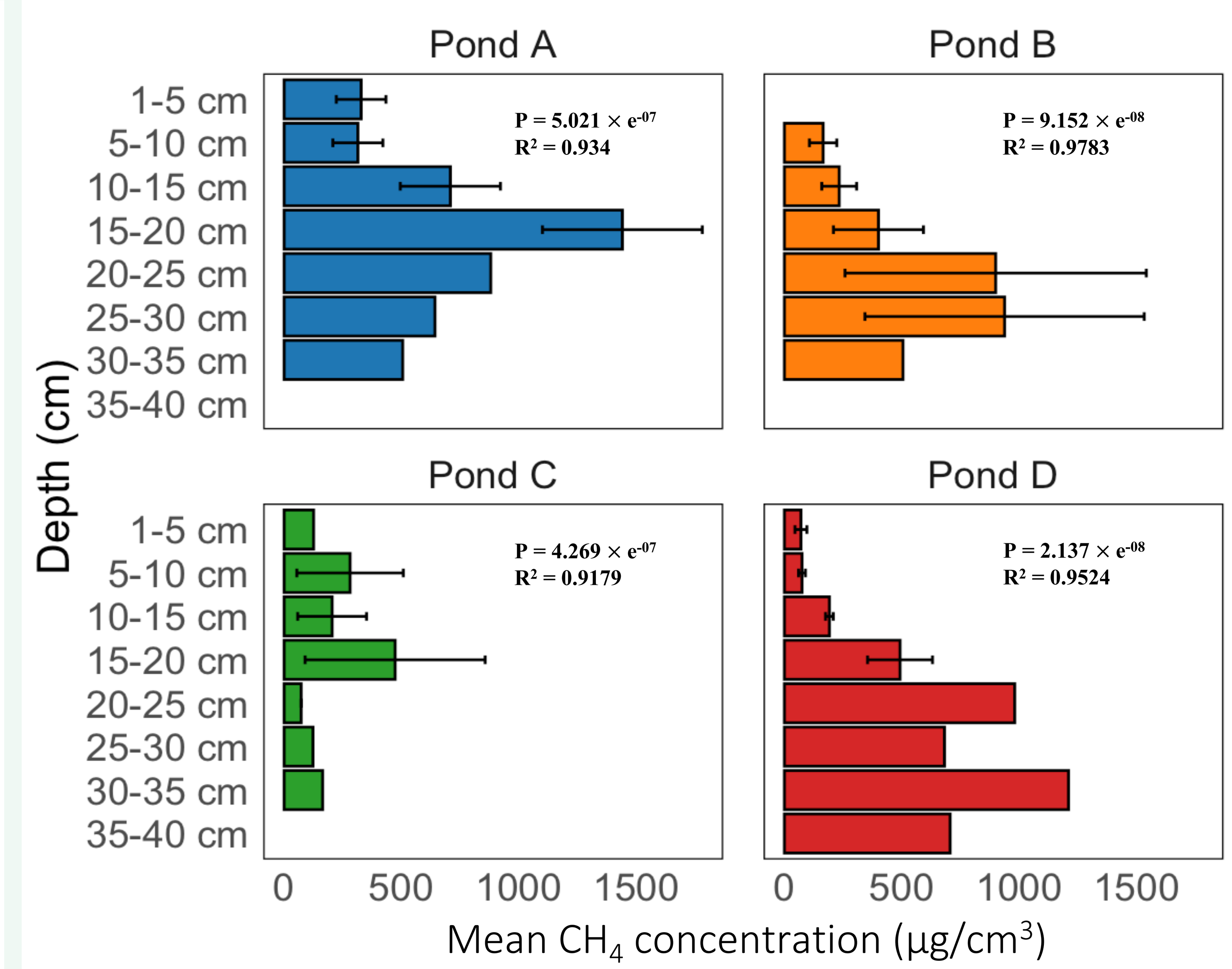

Figure 6: Depth (cm) and the mean CH_4 concentration (µg/cm³)

In ponds A and C, there was a positive correlation between CH_4 concentration and methanogen relative abundance

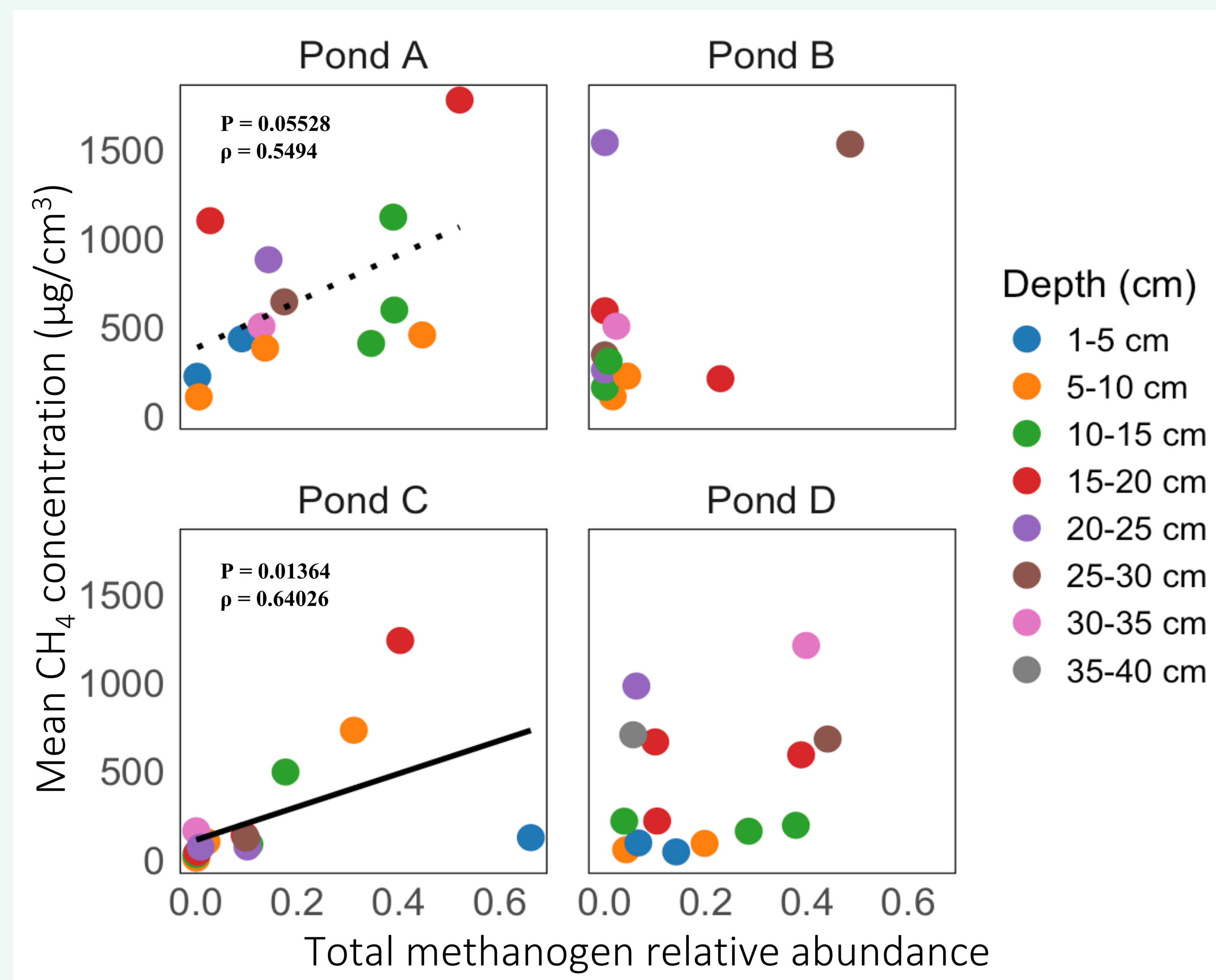

Figure 7: Mean CH_4 concentration (µg/cm³) and percent relative abundance of methanogens

The correlation between CH_4 concentration and depth (Figure 6) may reflect decreasing oxygen concentration (limiting methanogenesis at shallow depths with sufficient DOC and high oxygen) and subsequently decreasing DOC (limiting it at greater depths), creating an optimal zone for methanogenesis

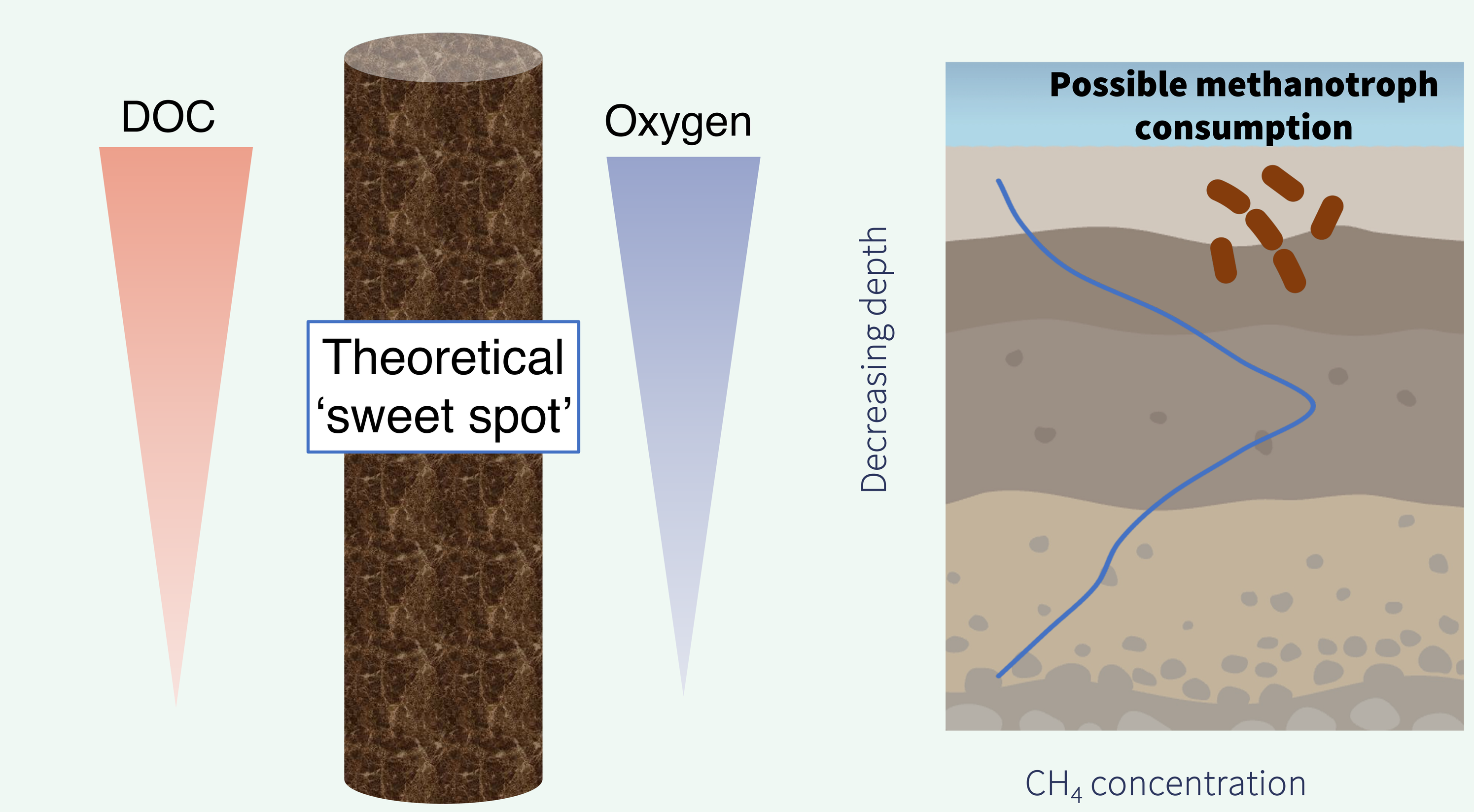

Figure 8: Dissolved organic carbon (DOC) levels decrease with increase in depth, a trend also observed for oxygen concentration.

Methanotrophs (which are aerobic) possibly consume methane emitted at the surface level, resulting in low methane concentrations.

Conclusion

- Methane production was likely driven by the availability of organic matter and the degree of anaerobic conditions.
- Greater methanogen relative abundance is not necessarily correlated with higher CH_4 concentrations.
- The environmental conditions conducive for methane production are more important than the abundance of methanogens themselves.
- Linking DOC data, oxygen concentrations, and other drivers of methanogenesis will help us understand how permafrost thaw affects methane production in Arctic thaw ponds.

Next steps

- Extract DOC measurements from soil cores to determine how it relates to CH_4 production at different depths.
- Perform similar analyses for potential nitrifiers and denitrifiers, which also contribute to greenhouse gas production cycles.

Acknowledgements and references

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