Changing greenhouse gas production within a thermokarst lagoon system, Reindeer Island, Mackenzie Delta, Canada

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The permafrost carbon pool is an important storage of the terrestrial carbon cycle that is at risk as the Arctic rapidly warms. Accordingly, in 2019, the United Nations Environmental Program identified permafrost thaw as one of the top five emerging environmental issues of global concern (UNEP, 2019).

In addition to increasing microbial decomposition of organic material and greenhouse gas release, permafrost thaw also leads to surface changes. Thermokarst lakes and basins are the result of the decrease in soil volume by melting ice in the subsurface. Rising sea levels and coastal erosion lead to the flooding of thermokarst lakes or drained lake basins along the ice-rich permafrost coasts of Siberia, Alaska and Canada, leading to the formation of thermokarst lagoons. These Arctic lagoons form a transition zone between the terrestrial and marine permafrost regime and represent an ideal research object for how permafrost carbon is affected by increasingly marine conditions. Due to current and future climate change in the Arctic, it is expected that the formation and development of thermokarst lagoons will accelerate (Jenrich et al. 2021). So far, thermokarst lagoons and their role in climate change have hardly been explored.

During one of the earliest studies on thermokarst lagoons Solomon et al. (2000) analyzed sediment cores taken in 1993 in a lagoon system at Reindeer Island at the North Head of the Mackenzie Delta, Canada (Figure 1). In 2021, we revisited this study area and took four sediment cores at the approximate same positions (3, 4, 5, 7) of this prior study and by comparing the same parameters (grain size, geochemistry, salinity, water and carbon content) we aim to investigate how sediment, carbon and porewater characteristics changed between 1993 to 2021. Further, we took additional sediment cores in the lagoon system (12-16).

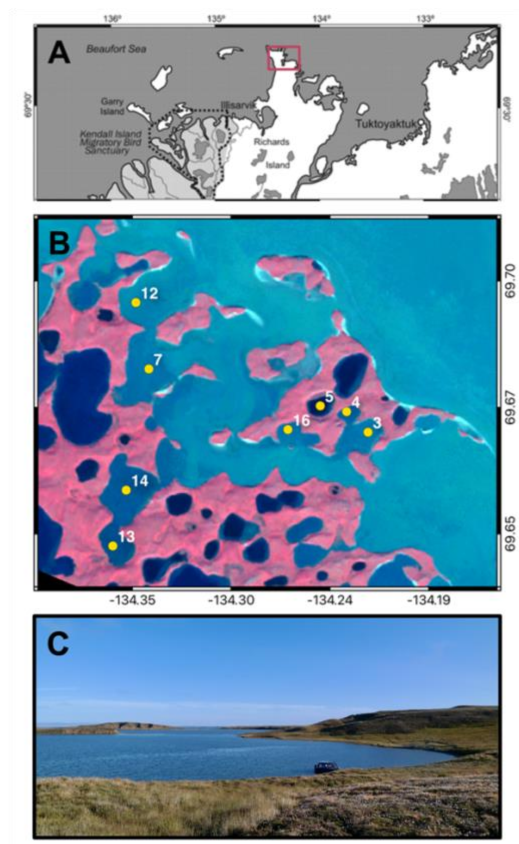

Figure 1. A: Location of the study site at the northern part of Richard Island, Mackenzie Delta, Canada. B: Coring locations (yellow dots) of this study. The locations 3,4,5 and 7 are comparable to the ones from Solomon et al. (2000). C: Photo taken from the western shore of Lagoon 4 overlooking lagoons 4 and 3. Source imagery: A: modified after Burn 2009, B: Sentinal 2 A false colour satellite image, aquired 2021-08-26, C: Photo by M. Jenrich 2021-08-21

To investigate the greenhouse gas production under varying degrees of seawater influence, and thus to assess whether the organic material in thermokarst lagoons is degraded on different temporal scales, we incubated the surface sediment below the lagoons with artificial sea water at two concentrations (brackish 13 g/L and marine 36 g/L) anaerobic at 4°C for 1 year. Here brackish conditions are considered as near natural conditions and represent the greenhouse gas production in the current state, while marine conditions represent the greenhouse gas production after the transition into a subsea state.

First results of the incubation experiment show that the greenhouse gas production is depending more on the location, thus microbial community and/or carbon degradability, than the salinity treatment. Highest methane and carbon dioxide production was measured at location 13, which is the youngest lagoon, least connected to the sea.

In conclusion, we expect that coastal permafrost erosion is leading to higher sediment and organic carbon input and newly formed thermokarst lagoons produce more greenhouse gases than older, more connected lagoons.

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