

Evolution of iron-organic carbon interactions during abrupt thaw in ice-rich permafrost: case study in Siberia

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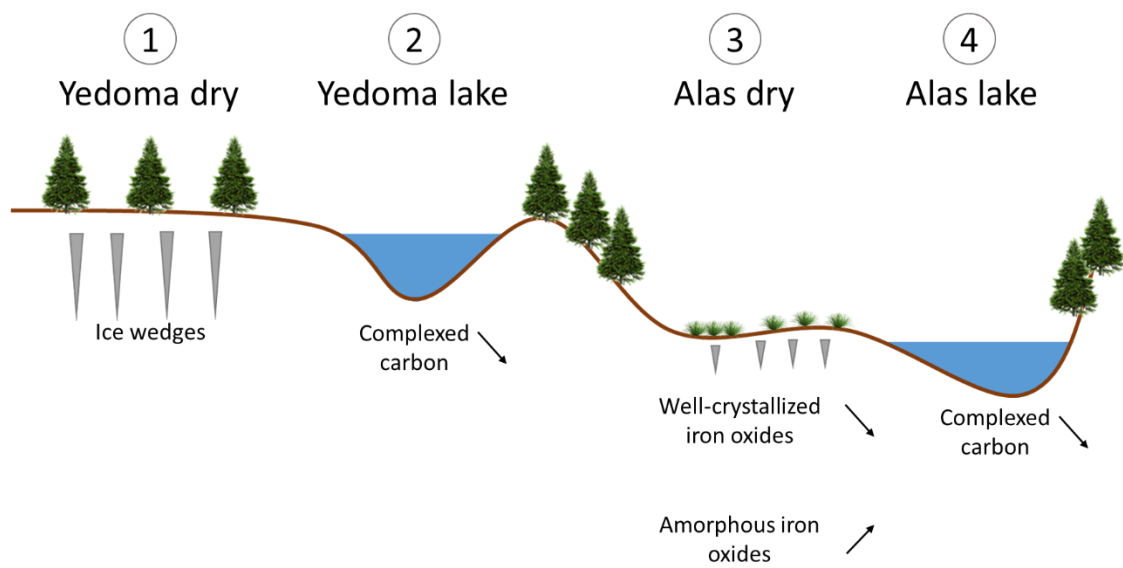
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Permafrost are permanently frozen ground found in northern latitudes. Deposits in permafrost regions store significant amounts of carbon, estimated at 1400 - 1600 GtC. Yedoma deposits, defined as ice-rich permafrost, contribute significantly to this carbon stock. With global warming, Yedoma deposits are likely to undergo abrupt thaw leading to thermokarst collapse, resulting in the formation of Alas deposits. The organic carbon stored in these frozen deposits could be exposed to microbial mineralization upon thaw, be released as CO₂ or CH₄ in the atmosphere and amplify global warming. However, many uncertainties remain on the subject, including the role of mineral elements on the mineralization rate of this carbon.

This study focuses on the evolution of the different forms of iron (i.e., crystalline, amorphous or complexed forms) during abrupt thaw of an ice-rich permafrost profile and its impact on organic carbon release. We analyzed four sediment cores from central Yakutia (Siberia) representative for progressive stages of thermokarst processes (i.e., Yedoma dry, Yedoma lake, Alas dry and Alas lake). The concentrations of total iron and iron selectively extracted using dithionite-citrate-bicarbonate (DCB), ammonium oxalate, and Na-pyrophosphate were measured. The organic carbon bound to these iron pools was also selectively extracted. We found i) a lower concentration of well-crystallized iron in Yedoma deposits that have already undergone abrupt thawing during the Holocene, and ii) a lower concentration of complexed carbon in samples underneath lakes, under anoxic conditions, compared to samples from drier areas (Figure 1).

References

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Modified from Windirsch et al., 2020

Figure 1. Schematic of the evolution of iron and carbon within the deposits from the four sampling site (Yukechi, Siberia): 1) Yedoma dry, 2) Yedoma lake, 3) Alas dry and 4) Alas lake.