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Thermokarst lake dynamics and its influence on biogeochemical sediment characteristics

- A case study from the discontinuous permafrost zone in Interior Alaska -

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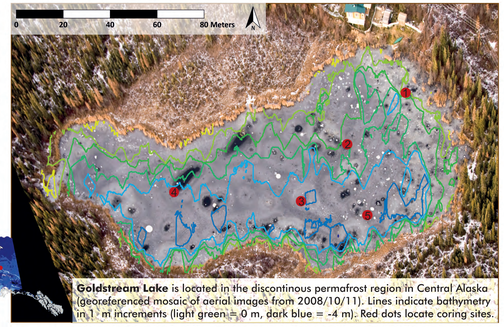
Background

Under currently projected scenarios of climate warming, discontinuous warm permafrost in Interior Alaska is expected to experience widespread disappearance. Thermokarst ponds and lakes are evidence for rapid permafrost thaw and amplify deep thaw by talik development. During the thawing process, previously preserved organic matter is made available for decomposition and former permafrost carbon is potentially released as greenhouse gases carbon dioxide and methane. In the course of lake development and shoreline expansion, both, younger near-surface and older organic matter from slumping shores are potentially deposited in the lake basin. Lake internal bioproductivity is complementing carbon accumulation in lacustrine deposits and provides an additional source of young carbon.

The case study of Goldstream Lake was choosen to find answers to the following questions:

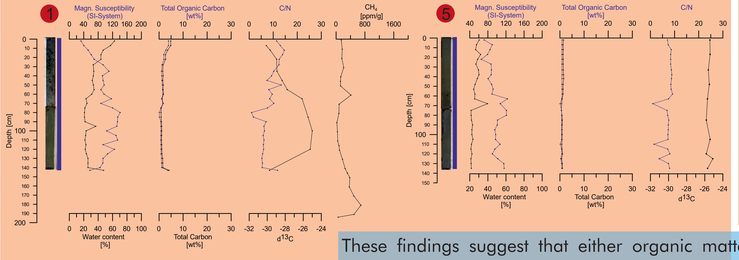
What are the main organic matter sources in Goldstream Lake?

How much carbon was accumulated, potentially decomposed and is currently stored in lake sediments?



Goldstream Lake is located in the discontinous permafrost region in Central Alaska (georeferenced mosaic of aerial images from 2008/10/11). Lines indicate bathymetry in 1 m increments (light green = 0 m, dark blue = -4 m). Red dots locate coring sites.

Near-shore deposits: Low carbon deposition



Total carbon contents are surprisingly low, both in near-shore and central-lake deposits:

- near-shore deposits from the active eastern shore have an organic carbon content of 1.4±1.0 wt.% in core 1 and 1.5± 1.7 wt.% in core 5
- lake-central deposits show a higher variability with an organic carbon content of 1.8±3.8 wt.% and maxima of 29 wt.% in core 3
- Further, the CH_4 concentration in sediments is rather low with 214±176 ppm/g in core 1 and 772±297 ppm/g in core 3

These findings suggest that either organic matter is decomposed very rapidly or sediment input in Goldstream Lake is generally minerogenic dominated and, thus, may not provide sufficient food source for microbes to produce such methane seeps observed from bubbles in lake ice in fall (see aerial image).

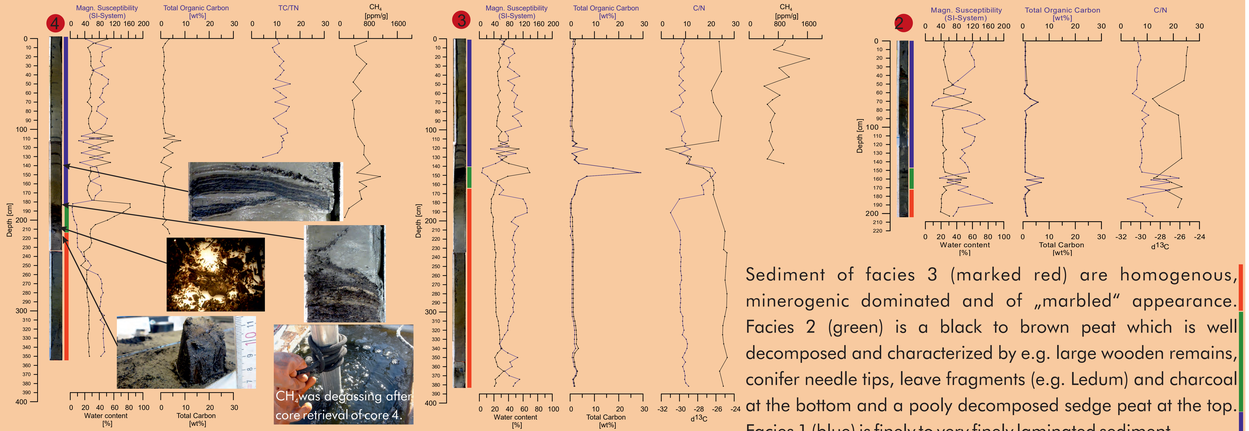
Material & Methods

5 sediment cores were retrieved from Goldstream Lake by using a hammer piston corer for short and a vibracorer for longer sediment cores. Samples for CH_4 concentration were taken right after core retrieval in head space vials. Cores were described, subsampled and analyzed for magnetic susceptibiltity, total organic carbon content based on the principle of combustion chromatography, C/N ratio and stable carbon isotopes.

Lake-central deposits: One or two lake generations?

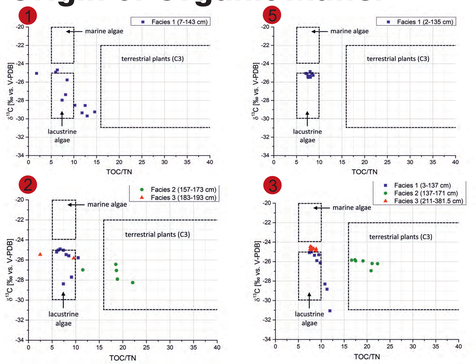
The ratios of $d^{13}C$ and C/N as well as plant macrofossils give evidence for either

1) an intermediate terrestrial phase (facies 2) underlain by an early lake generation (facies 3) or
2) a first lake generation (facies 1& 3) including an ex-situ deposition of terrestrial soil



Sediment of facies 3 (marked red) are homogenous, minerogenic dominated and of „marbled" appearance. Facies 2 (green) is a black to brown peat which is well decomposed and characterized by e.g. large wooden remains, conifer needle tips, leave fragments (e.g. Ledum) and charcoal at the bottom and a pooly decomposed sedge peat at the top. Facies 1 (blue) is finely to very finely laminated sediment.

Origin of Organic Matter



Acknowledgements

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