Past Permafrost and Landscape Dynamics in Central Beringia: Two Case Studies from Drained Thermokarst Lake Basin Cores

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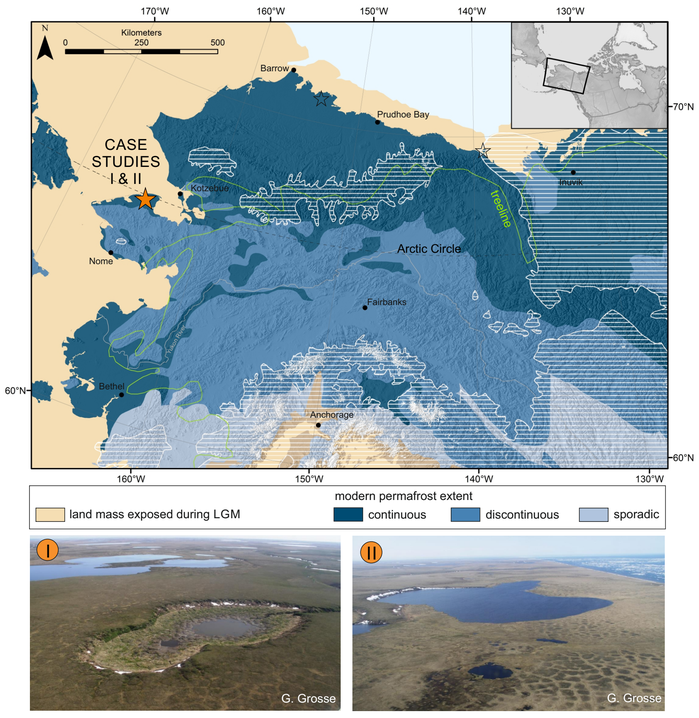
INTRODUCTION

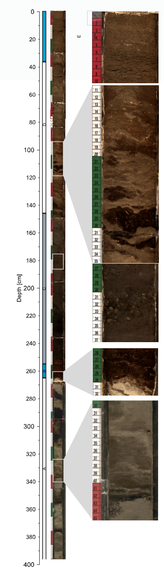
Thermokarst is a commonly observed process in the Arctic and an indicator of permafrost degradation. The formation of thermokarst landforms may indicate a localized disturbance to the ground thermal regime or be indicative of widespread permafrost degradation driven by climate-induced top-down permafrost thaw. In our study, we investigate two drained thermokarst lake basins on the northern Seward Peninsula in Central Beringia to gain insights into site-specific landscape development and past permafrost dynamics during glacial and interglacial periods.

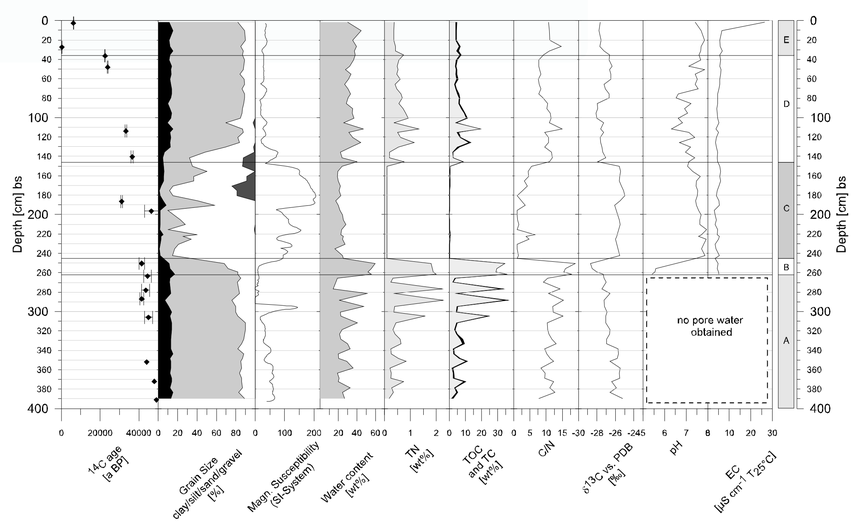


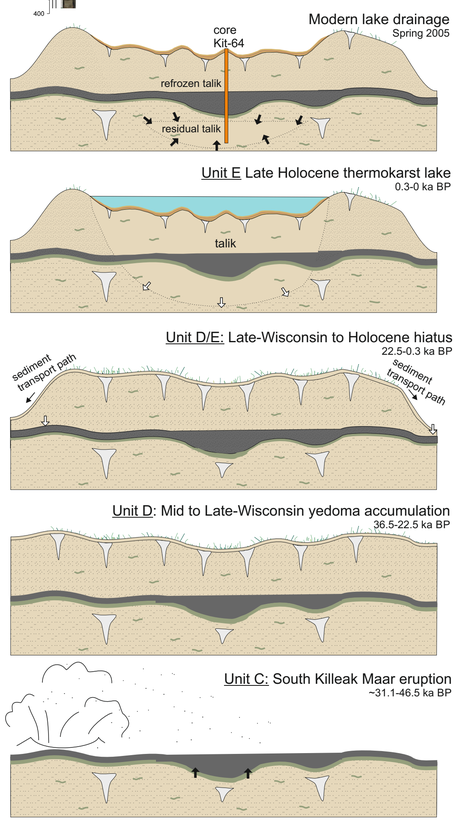
STUDY AREA

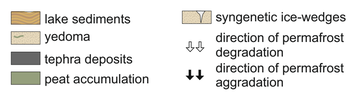
The study region of the Northern Seward Peninsula is part of the Bering Land Bridge National Preserve and remained unglaciated during the Last Glacial Maximum. It represents one of Alaska`s major lake districts and is underlain by ~100 m of continuous, ice-rich permafrost called yedoma.
A 350 cm permafrost core (ID: Kit-43) and a 400 cm permafrost core (ID: Kit-64) were acquired from two drained lake basins that represent contrasting geological settings and cover a range of time periods (Mid-Wisconsin to Holocene). Kit-64 was a first generation lake in yedoma upland; Kit-43 was a later generation lake in a thermokarst-shaped lowland.

CASE STUDY I



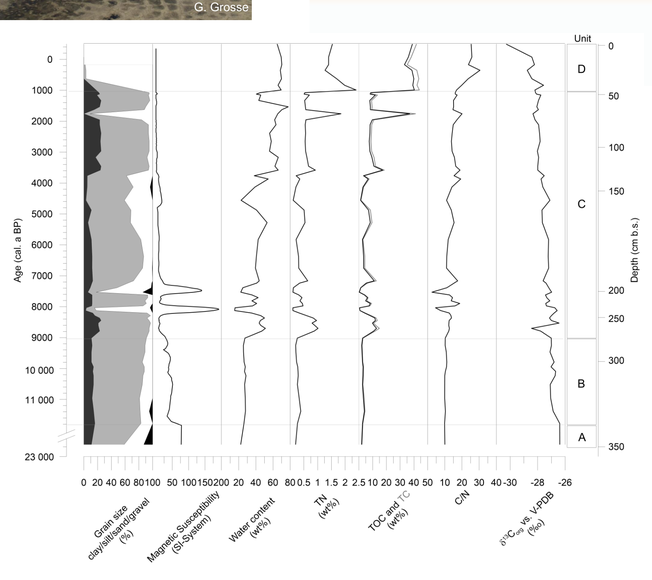


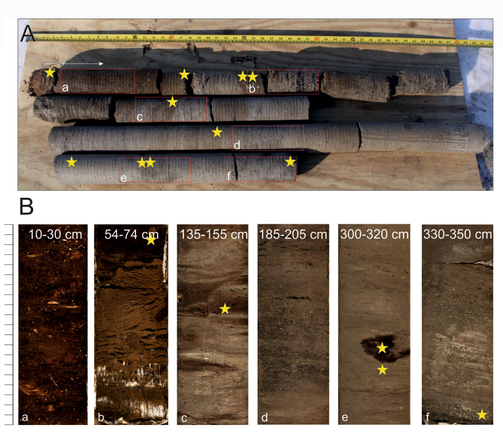




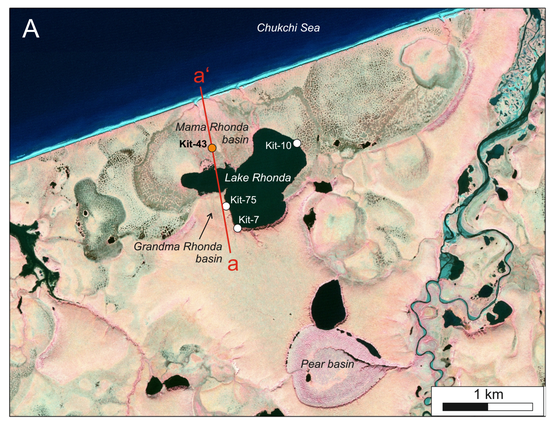
The Kit-64 core was acquired from a first generation lake basin on a yedoma upland that preserved a depositional environment of **more than 45,000 years** including:
(A) Mid-Wisconsin **yedoma** accumulation,
(B) intermediate **wetland development** between 41,500 and 44,500 yr BP,
(C) South Killeak Maar **tephra deposition** that interrupted the wetland development,
(D) continued terrestrial yedoma accumulation probably until the Late Glacial when a significant gap in the sedimentary record indicates **formation of thermokarst** lakes in the surroundings of this site that prevented further accumulation, and
(E) finally a **300 cal yr BP thermokarst lake** initiated and rapidly grew at the site which then **drained in AD 2005.** Modern permafrost aggradation is indicated in core Kit-64 however, unfrozen talik sediments were still present below a depth of 266 cm four years after drainage.

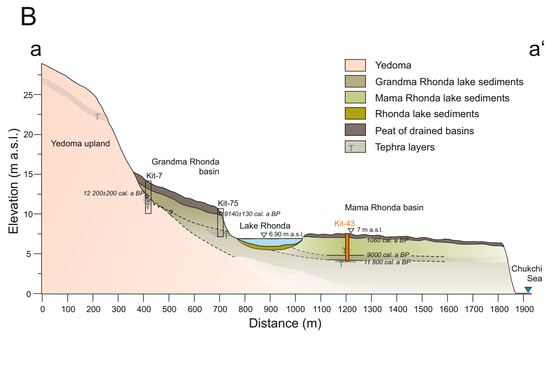
CASE STUDY II





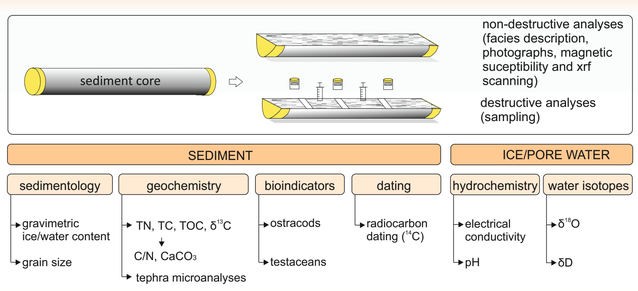
The Kit-43 core archived **11,800 cal yrs BP of predominately lacustrine deposition** including:
(A/B) **Late Glacial thermokarst initiation** and development of a deep thermokarst lake,
(C) Early Holocene transition to a second, large and more **dynamic lake generation by 9,500 cal yr BP** with water level changes and intermediate wetland phases and tephra redeposition from the catchment and
(D) Late Holocene **complete drainage at 1,060 cal yr BP** with subsequent peatland development. Interestingly, the isotopic composition of the intrasedimentary ice does not only capture the filling of the modern active layer by summer precipitation but also preserve similar patterns for the paleo-active layer 42-82 cm below modern surface, as well as **permafrost aggradation in the refreezing paleo-lake talik** from the surface down to 154 cm. The presence of multiple lake cycles in the Kit-43 core, emphasizes the **complexity of organic carbon trajectories** in thermokarst lake environments.





METHODS

We applied a multi-proxy approach on two 4 m and 3.5 m long sediment cores covering the following methods:



CONCLUSION

These two case studies reveal the **complex nature of Arctic landscapes** that are affected by permafrost degradation and aggradation during a time when first humans migrated from Eurasia through North-America. They also highlight the **interaction of global climate change, regional environmental dynamics, and local disturbance processes** on different temporal scales. The maturation of landscapes by thermokarst dynamics on local level can have a **significant influence on regional to global biogeochemical cycles**.

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11th International Conference on Permafrost 2016, Potsdam/Germany, June 20-24