Understanding Thermokarst Lake Dynamics in Arctic Alaska: A Case Study based on Sediment Cores

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INTRODUCTION

Arctic landscape dynamics are an indicator of global climate change. The degradation of ice-rich permafrost since the Pleistocene-Holocene transition was responsible for the formation of numerous thermokarst lakes in the Arctic. However, these lakes typically undergo a cycle of initiation, expansion, drainage, and re-initiation that may or may not be coupled to global change or local disturbances. Our study of a recently drained lake basin in Arctic Alaska (USA) provides insights into past landscape dynamics in the continuous permafrost region to answer the questions: How did thermokast develop in the past? What triggers Arctic lake development? Climate changes or local disturbances?

STUDY AREA

The study region of the Northern Seward Peninsula is part of the Bering Land Bridge National Preserve and remained unimpacted 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. The studied sediment core (core ID: Kit-64) was recovered from a 12 ha thermokarst basin which drained in Spring 2005.

METHODS

We applied a multi-proxy approach on a ~4 m long sediment core covering the following methods:

- High-resolution age determination
- Micropaleontology
- Sedimentology
- Biogeochemistry
- Remote sensing

RESULTS

Unit A: Early to Mid-Wisconsin yedoma accumulation
- Silty sediments with interbedded organic-rich material
- Yedoma accumulation in cold and dry climate conditions (transferred to unfrozen talbot due to talk development/unit E)

Unit B: Mid to Late-Wisconsin yedoma accumulation
- Peaty layer with high TOC contents of 29-35 wt%, high C/N ratio
- High bioproductivity by local wet conditions causing initial ponding

Unit C: South Killeak Maer eruption
- 1-m air-fall tephra with particles up to 7 mm
- Associated with the 42 ka BP South Killeak Maar eruption of regional scale
- Terminated potential thermokarst development

Unit D: Late-Wisconsin to Holocene hiatus
- Silt with intermediate organic layers (similar to unit A)
- Generally cold and dry circumpolar climate conditions allow terrestrial yedoma accumulation with seasonally wet phases

Unit D/E: Late-Wisconsin to Holocene hiatus
- Depositional hiatus 22.5 ± 0.16 and 0.23 ± 0.03 ka BP

Unit E: Late Holocene thermokarst lake
- Distinct lamination, mollusk shells as well as well preserved ostracods
- Indicate shallow, cold freshwater ecosystem of 300 yrs duration
- Local permafrost disturbance due to global climate amelioration

Modern lake drainage: Spring 2005

DISCUSSION

We investigated lake development in the permafrost-affected terrestrial Arctic. Our study emphasizes that Arctic lake system and periglacial landscapes are dynamic and sensitive to rapid change.