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THERMOKARST LAKE SEDIMENT AS INDICATOR OF CLIMATE VARIATIONS: PRECISE ENVIRONMENTAL ARCHIVE OR WISHFUL THINKING?

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In polar permafrost environments lake sediments are commonly used to reconstruct past environmental conditions and are sometimes the only high-resolution and continuous archive available where ice caps, glaciers or trees are missing. However, many of the lakes from the Arctic lowlands of Siberia, Canada and Alaska are of thermokarst origin. That means they originate from surface subsidence after melt-out of permafrost ground ice; a process that started with the onset of the Holocene and that is still ongoing today. Although these lakes contain a sedimentary record that has archived environmental processes since lake genesis, thermokarst lakes are dynamic systems. On the one hand they can be expected to respond rapidly to environmental change, but on the other hand their response is greatly determined by landscape dynamics and morphological change rather than responding to climate variables in terms of temperature and precipitation.

Here we present a multidisciplinary study on the sedimentary record of a thermokarst lake in the western Canadian Arctic. We applied sedimentological and geochemical tools measuring XRF, grain-size distribution, carbon and nitrogen contents, and $\delta^{13}C$ signatures. We examined radiographic images and pore water hydrochemistry. Pollen and ostracod assemblages provided quantitative and qualitative climate reconstructions.

Thermokarst lakes, in contrast to non-thermokarst lakes, receive most of the bottom sediments from its own eroding shorelines. Therefore, they mostly recycle old deposits, a fact that complicates absolute dating efforts. Not only the minerogenic fraction of lake sediments is strongly influenced by catchment deposits but also the fossil assemblage. The sediment transport path is short so that also fragile fossils may survive re-deposition and therefore make interpretations on climate proxy data complicated. Based on differences in grain-size distribution, XRF spectra and carbon and nitrogen contents we can track several major stages in lake development that do not necessarily correspond to climate variation. This highlights the complex nature of thermokarst lake development with processes that occur in degrading permafrost landscapes only such as:

- freeze-through and grounding of lake ice at shallow water depths and initial lake stages
- increasing lake area through rapid and sometimes directed shoreline erosion
- increasing water depth through thaw subsidence and talik growth
- episodic sediment re-mobilization along changing slope gradients.

Although thermokarst lake sediments might not be the best climate archive, they are sometimes the best we can find, and they can provide high-resolution records of the Holocene. It is worth studying the onset, life cycle, and development of thermokarst lakes as they play a crucial role in Arctic freshwater ecosystems and in the global carbon cycle of the past, present and future.