Thermokarst lake development in syngenetic ice-wedge polygon terrain in the Eastern Canadian Arctic during the Holocene

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Résumé

Thermokarst lakes are ubiquitous across permafrost regions and they are considered significant contributors to global greenhouse gas emissions. Paleoenvironmental reconstructions documenting the inception and development of these water bodies are generally limited to Pleistocene-age permafrost deposits (Yedoma) of Siberia, Alaska, and the western Canadian Arctic. Here we present the gradual transition from syngenetic ice-wedge polygon terrains to a thermokarst lake in the Eastern Canadian Arctic. We combine geomorphological surveys with paleolimnological reconstructions from sediment cores in an effort to characterize local landscape evolution from terrestrial to freshwater environment. Located on an ice-rich and organic-rich polygonal terrace, the studied lake is now evolving through active thermokarst, as revealed by subsiding and eroding shores, and was likely created by water pooling within a pre-existing topographic depression. Organic sedimentation in the valley started during the mid-Holocene, as documented by the oldest organic debris found at the base of one sediment core and dated at 4.8 kyr BP. Local sedimentation dynamics were initially controlled by fluctuations in wind activity, local moisture and vegetation growth/accumulation, as shown by alternating loess (silt) and peat layers. Fossil diatom assemblages were likewise influenced by local hydro-climatic conditions and reflect a broad range of substrates available in the past (both terrestrial and aquatic). Such conditions likely prevailed until _˜ 2000 BP, when peat accumulation stopped as water ponded the surface of degrading ice-wedge polygons, and the basin progressively developed into a thermokarst lake. Interestingly, this happened in the middle of the Neoglacial cooling period, likely under wetter-than-average conditions. Thereafter, the lake continued to develop as evidenced by the dominance of aquatic diatom taxa in organic-rich lacustrine muds. Based on these interpretations, we present a four-stage conceptual model of thermokarst lake development during the Holocene, including potential future trajectories. Such a model could be applied to other formerly glaciated permafrost landscapes.

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