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The paleoecology, peat chemistry and carbon storage of a discontinuous permafrost peatland

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Permafrost in peatlands strongly influences ecosystem biogeochemical functioning, vegetation composition and hydrological functions. Permafrost peatlands of northwestern Canada store large amounts of carbon but the peatlands located at the southern margin of the permafrost zone are thawing rapidly. This thaw triggers changes in vegetation, hydrology and peat characteristics, and may affect carbon stocks.

We present data from a permafrost plateau to thermokarst bog chronosequence located in the southern portion of the Scotty Creek watershed near Fort Simpson, Northwest Territories, Canada. We assessed changes in plant communities, hydrology, biogeochemistry and permafrost status over ∼9000 years of peatland development using plant macrofossil, testate amoeba and peat chemical characteristics.

Peat accumulation started after the infilling of a lake ∼8500 cal. yr BP. Minerotrophic peat prevailed at the site until permafrost formed around 5000 cal. yr BP. Permafrost apparently formed three times, although there is spatial variability in the permafrost aggradation – degradation cycles. Permafrost thawed ∼550 cal. yr BP in the center of the thermokarst bog. Ombrotrophic peat is a fairly recent feature of the peat profiles, only appearing after the most recent permafrost thaw event. Both allogenic (temperature/precipitation/snow cover changes and wildfire) and autogenic (peat accumulation, Sphagnum growth) processes likely influenced permafrost aggradation and thaw.

While apparent carbon accumulation rates were lower during present and past permafrost periods than during non-permafrost periods, long term carbon accumulation remained similar between cores with different permafrost period lengths. Deep peat was more decomposed in the thermokarst bog peat profile than in the permafrost plateau profile, highlighting the importance of considering potential deep peat carbon losses to project the fate of thawing permafrost peat carbon stores. Average long-term carbon accumulation derived from the peat cores (n=3, 20.6 $\pm$ 1.9 g C m-2 a-1) is in the same range than the contemporary landscape-scale carbon balance measured from eddy covariance at the site (∼15 g C m-2 a-1). While the carbon to nitrogen ratio tends to decrease with peat depth, the carbon to phosphorus ratio tends to increase, perhaps indicating a preferential uptake of phosphorus over nitrogen by plants.