Carbon accumulation patterns and peat fires under Holocene climate fluctuations in boreal bogs, James Bay region, Québec, Canada

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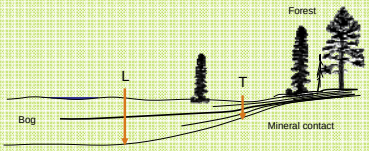
INTRODUCTION

Peatlands are ecosystems that accumulate organic carbon (C) as production exceeds decomposition. Ombrotrophic peatlands are exclusively dependent on precipitation and therefore form sensitive records of hydroclimatological conditions. Thus, during dry episodes, peat has a potential for burning. The interactions between climate, vegetation and fire on millennial timescales concerning peat fires are complex. The aim of the project is to improve the comprehension of peat fire regimes and their influence on carbon accumulation under Holocene climate variations. Because of spatial variability in peatland vegetation, peat fire dynamics may well differ from those in forests. C accumulation patterns obtained from the three studied bogs are presented with fire and vegetation reconstructions from Lac Le Caron bog.

METHODS

Fire reconstruction

- Four lateral cores (core L) and four transition cores (core T) per peatland along a forest-bog gradient;
- Macro-charcoal analysis (>355 µm; 2 cm³ sample; 1 cm resolution);
- AMS ^{14}C dating (33 datings at present) and calibration using BCal (Buck *et al*., 1999).



Lateral cores are sampled at the forest-bog transition (core T) and where peat accumulation reaches ~2 m (core L)

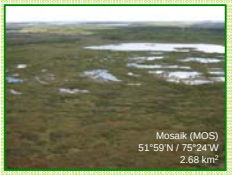
Carbon accumulation, vegetation development and water table reconstructions

- Central core (core C) for maximum peat depth;
- LOI and bulk density analysis (1 cm resolution);
- Plant macrofossil analysis (4 cm resolution);
- Testate amoebae analysis (4 cm resolution) and application of a transfer function (Booth, 2008);
- AMS ^{14}C dating (27 datings at present) and calibration using BCal (Buck *et al*., 1999).

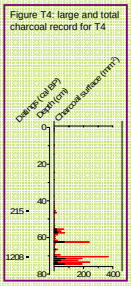
STUDY REGION

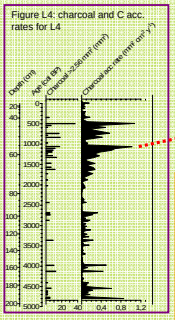
The studied bogs are located in the Eastmain-1 region, Québec, near the transition of the closed crown forest to the lichen woodland.

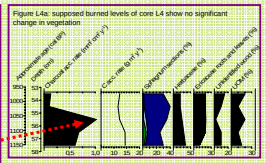
The Eastmain-1 region with the locations of the studied bogs

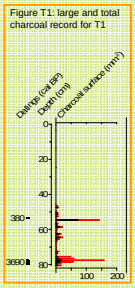


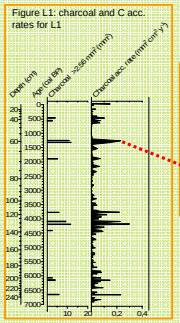
FIRE HISTORY AND VEGETATION AND HYDROLOGY RECONSTRUCTION FROM LAC LE CARON BOG

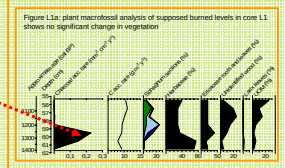


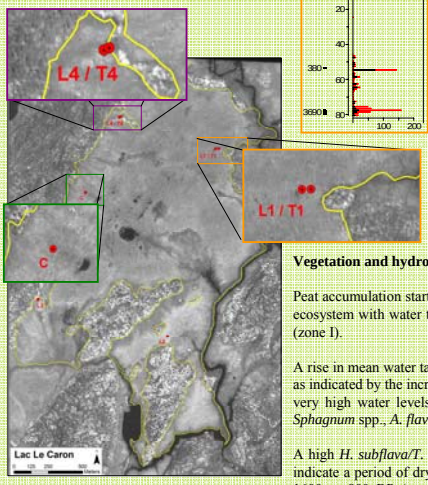












Fire history

Charcoal analysis shows a period of probable peat burning from 2000 to 400 BP by an increased presence of fragments (Figures L1 and L4).

Plant macrofossil analysis performed above and below charcoal horizons fails to indicate shifts in vegetation assemblages and C accumulation (Figures L1a and L4a).

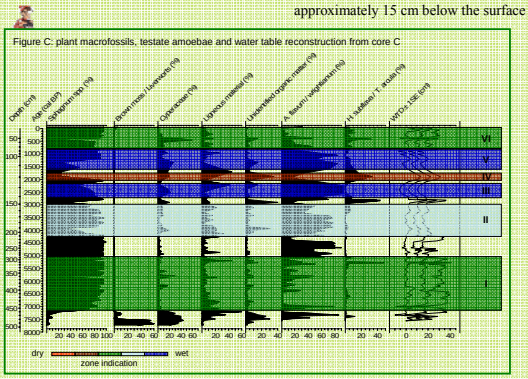
Cores T1 and T4 from the forest-bog transition show important increases in peat accumulation since ~300 BP with an absence of fire events (Figures T1 and T4).

Vegetation and hydrology reconstruction

Peat accumulation starts around 7530 BP with a short fen-phase (7530-7100 BP; Figure C). A bog ecosystem with water tables varying from 15 to 20 cm below the surface is present until 5000 BP (zone I).

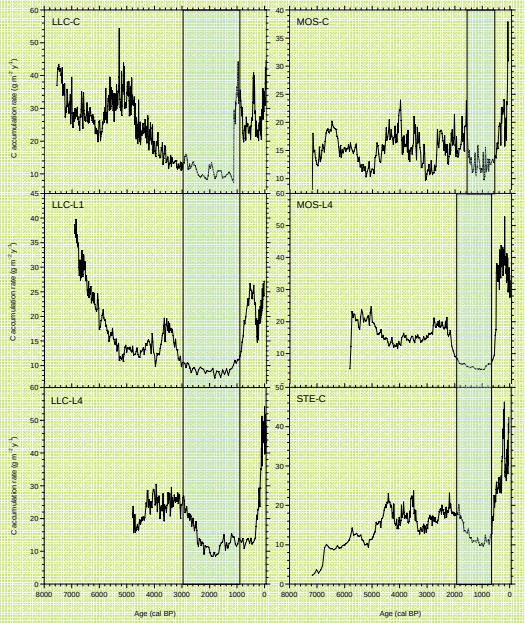
A rise in mean water table occurs around 5000 BP but is more pronounced from 4200 BP (zone II) as indicated by the increase of *A. flavum/wrightianum* testate amoebae. Between 2700 and 2200 BP very high water levels (mean depth of 3 cm) are recorded as shown by the abundance of wet *Sphagnum* spp., *A. flavum/wrightianum* testate amoebae and Cyperaceae (zone III).

A high *H. subflava/T. arcula* testate amoebae representation and high unidentified organic matter indicate a period of dry conditions (2000 – 1800 BP; zone IV). A second wet period extends from 1600 to 800 BP (zone V). Finally, from 800 BP to present the mean water table remains at approximately 15 cm below the surface (zone VI).



Western part of the Lac Le Caron bog showing a sharp forest-bog transition. Burned trees result from a fire in 2002, however, the bog remained untouched.

LONG TERM RATE OF C ACCUMULATION (LORCA) FROM LAC LE CARON (LLC), MOSAIK (MOS) AND LA STERNE (STE) BOGS



Mean LORCA varies between 15.3 and 22.8 g m^{-2} y^{-1}. Except MOS-C, analyzed cores show comparable periods of low C accumulation rates (7 - 14 g m^{-2} y^{-1}), however varying in duration. This period extends from 2900 to 900 BP in LLC cores and between 2000 and 700 BP in MOS-L4 and STE-C cores. These low rates are comparable to those measured in minerotrophic peatlands in the subarctic region of Québec (Garneau *et al*., 2007). Cooler and wetter conditions may have influenced the growing season and related vegetation communities. This hypothesis is supported by the plant macrofossil record and reconstructed high water tables from LLC-C.

DISCUSSION AND CONCLUSION

An important period of higher fire activity and low C accumulation is found roughly between 2000 and 700 BP. However, no direct link can be established because high-resolution plant macrofossil analysis does not indicate a clear shift in vegetation composition resulting from a single fire event.

Another explanation for the observed patterns may be a change in climate. Neoglacial cooling may have caused decreased C accumulation, with delays recorded in cores MOS-C and STE-C. During this period, higher forest fire activity has been recorded in the lake records of the Québec southern boreal forest (Carcaillet *et al*., 2001).

In peatlands, a change in vegetation can cause an increased potential for biomass burning (Benscoter and Wieder, 2003). In addition, hollow vegetation may dry out more rapidly during dry and warm summers because of its low water-retaining ability.

Future analyses of macro-charcoals and plant macrofossils supported by radiocarbon datings will allow a better understanding of peat fire, vegetation and climate dynamics in the region.

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