Reconstructing the history of atmospheric metal deposition from analysis of ombrotrophic peatlands along the St. Lawrence Valley

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Introduction
On a global scale, human activities affect the geochemical cycles of potentially toxic trace elements [1], with profound implications for the Biosphere [2].

Ombrotrophic peatlands (bogs) are underutilized and frequently overlooked terrestrial archives for the Holocene.

As peat bogs are only fed by atmospheric precipitations (i.e. aerosols, rain, etc.), they record a more local and synchronous signature than other continental ecosystems (e.g. river and lake sediments).

Objectives
- Reconstruct the history of atmospheric deposition of Pb, As, Cd, Zn and Ni since the onset of the Industrial Revolution from the upper (<1 m) horizons of peat bogs along the St. Lawrence Valley.
- Compare the deposition history of different sites within St. Lawrence Valley along a southwest-northeast transect.
- Identify the sources of these metals and their regional and anthropogenic signatures.

Study sites

Methods
Surface cores were retrieved from each site using a PVC pipe (Mirabel Frontenac) and a stainless steel box corer (Baie, Mer Bleu) (Fig. 1).

Samples were analysed for their metal contents (As, Cd, Ni, Pb and Zn) as well as other elements (Ca, Fe, Mn, Sc, Sr, Ti) using ICP-MS (Dept. Chemistry and Biochemistry, Concordia U.).

Chronologies were based on 207Pb and AMS 14C-dating carried out, respectively, at Laboratoire des Radio-isotopes (GEOTOP-UQAM) and KECK-CCAMS Lab (U. of California, Irvine, USA).

Enrichment factor (EF) relative to Upper Continental Crust (UCC) and cumulative anthropogenic accumulation of metal were calculated using Sc as a reference element [3, 4].

Results (Baie and Mirabel bogs)
Maximum concentrations of Pb, As, Cd are found between 24-28 cm at the Baie peatland and 25-35 cm at Mirabel. At both sites, concentrations of these elements are lower at top and bottom of the cores.

Zn shows higher concentrations at the surface of the Mirabel bog (Fig. 2).

With the exception of Pb, maximum metal concentrations are higher in the Mirabel than the Baie bog (Fig. 2).

The zone of Pb enrichment is broader than other metals in the Baie core (Table 1). The enrichment factor patterns for As, Cd, Pb and Fe (not shown) are similar at Mirabel.

At both sites, Pb accumulation rates increase from ca 1900 AD reaching maxima of 48.5 mg m⁻² yr⁻¹ in 1956 and 24.8 mg m⁻² yr⁻¹ in 1990 at Mirabel and Baie, respectively. Accumulation rates of other metals are typically one order of magnitude higher at Mirabel.

Cumulative atmospheric accumulation of metals is higher at Mirabel with Pb and Zn displaying the greatest mass accumulation at both sites (Fig. 3).

Discussion and Conclusions
Maximum Pb concentrations at Mirabel are similar to those reported in another study in Ontario (95-150 ug g⁻¹) [5] but higher than in New Brunswick (60 ug g⁻¹) [6].

The similarities in modern Pb, As, Cd (at both sites) as well as Ni and Fe (at Mirabel only) profiles suggest that –1 they have a predominant common source; 2) they behave similarly in peat bogs, or both. With the possible exception of Ni, enrichment factor patterns for these metals are very similar.

This surface enrichment in Zn at Baie and Mirabel peatlands is likely explained by a bioaccumulation by plant [7, 8]. This renders the reconstruction of the history of deposition more difficult.

Pre-anthropogenic concentrations of metals in the Baie core seem to be mainly controlled by dust deposition, as they follow Sc and ash content closely. This peatland sits near the coast along the St. Lawrence Estuary.

The cumulative metal deposition and accumulation rates at Mirabel reveal that this site was more impacted by anthropogenic sources, possibly due to both longer exposition to anthropogenic metals and its proximity to urban centres.

To better understand the differences in metal deposition between sites, stable lead isotope analyses are being carried out to identify the sources of the pollutants and explain their temporal variations.

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References

Figure 1: Location of the 4 study sites

Figure 2: Ash content and element concentrations for Baie(A) and Mirabel(B)

Table 1: Summary of data of enrichment factors of metals for both sites