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Holocene development of maritime ombrotrophic peatlands of the St. Lawrence North Shore in eastern Canada

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ABSTRACT

Macrofossil analyses were used to reconstruct long-term vegetation successions within ombrotrophic peatlands (bogs) from the northern shorelines of the St. Lawrence Estuary (Baie-Comeau) and the Gulf of St. Lawrence (Havre-St-Pierre). Over the Holocene, the timing and the ecological context of peatland inception were similar in both regions and were mainly influenced by fluctuations in relative sea level. Peat accumulation started over deltaic sands after the withdrawal of the Goldthwait Sea from 7500 cal yr BP and above silt–clay deposits left by the Laurentian marine transgression after 4200 cal yr BP. In each region, the early vegetation communities were similar within these two edaphic contexts where poor fens with Cyperaceae and eastern larch (*Larix laricina*) established after land emergence. The rapid transitions to ombrotrophy in the peatlands of Baie-Comeau are associated with particularly high rates of peat accumulation during the early developmental stage. The results suggest that climate was more propitious to *Sphagnum* growth after land emergence in the Baie-Comeau area. Macrofossil data show that treeless *Sphagnum*-dominated bogs have persisted over millennia and that fires had few impacts on the vegetation dynamics. This study provides insight into peatland vegetation responses to climate in a poorly documented region of northeastern America.

Introduction

Peatlands are an important feature of the boreal landscape in the Northern Hemisphere. Although peatland ecosystems cover only 3% of the Earth's land surface, they are one of the largest terrestrial carbon (C) sinks (Yu et al., 2009). Over the Holocene, the initiation and expansion of northern peatlands have played an important role in the global C cycle and feedbacks on climate change (Frolking and Roulet, 2007; Yu, 2011). In Canada, peatlands cover ~12% of the land area (~1.1 million km^2) and contain the equivalent of about half of the organic C stored in soils (Tarnocai et al., 2005). Peatlands are common in the maritime regions of eastern Canada and play an important role in terms of biodiversity, water storage and organic C sequestration (Damman, 1986; Garneau et al., accepted for publication; Glaser, 1992). Ombrotrophic peatlands (bogs) are widespread along the north shore of the St. Lawrence Estuary and Gulf of St. Lawrence in eastern Québec. These ecosystems cover deltaic sands that emerged from the Goldthwait Sea after ~9000 yr and silt–clay deposits left by the mid-Holocene Laurentian marine transgression (Dionne, 2001; Bernatchez, 2003). In spite of their ecological and spatial significance in the coastal plains, little is known about the development of these bogs over the Holocene. It is necessary to understand the factors influencing long-term vegetation dynamics in these peatlands to evaluate how they can be affected by environmental and climate changes.

Over the last decades, only few palaeoecological studies have been conducted in maritime bogs of eastern Canada (Tolonen et al., 1985; Garneau, 1998; Hughes et al., 2006; Robichaud and Bégin, 2009; Payette et al., 2013). Previous peatland paleoecological studies mainly focused on continental boreal regions of the James Bay and Hudson Bay Lowlands (Glaser et al., 2004; Arlen-Pouliot and Bhiry, 2005; Arlen-Pouliot, 2009; Beaulieu-Audy et al., 2009; van Bellen et al., 2011a; Bunbury et al., 2012; Lamarre et al., 2012; Magnan et al., 2012) and within the St. Lawrence Lowlands in southern Québec and eastern Ontario (Lavoie and Richard, 2000; Muller et al., 2003; Elliott et al., 2012; Lavoie et al., 2013). These studies showed that the rates and pathways of vegetation changes in peatlands are driven by a combination of internal processes (e.g., plant competition, peat build-up) and external factors (e.g., climate and fires). The long-term development of boreal and subarctic peatlands typically follows a hydroseral succession from minerotrophic (fen) to ombrotrophic conditions (bog). This isolation of peat-forming vegetation from nutrient-rich groundwater may result primarily from internal factors (Payette, 1988; Yu et al., 2003a) but can also be favoured by changes in the atmospheric moisture balance (Hughes and Barber, 2003).

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At the regional scale, the basin morphology and underlying sediment which control water supplies are important factors influencing the early peatland development (Bauer et al., 2003; Bhiry et al., 2007; van Bellen et al., 2011b; Ireland et al., 2013). The shape of the basin indirectly controls the long-term trends in peat accumulation and surface hydrology (Yu et al., 2003a; Belyea and Baird, 2006). However, the Holocene climate variations have also been an important factor controlling the initiation and expansion of northern peatlands (MacDonald et al., 2006; Korhola et al., 2010). In northern Québec, the active formation of peatlands between 6300 and 4200 yr coincided with the Holocene Thermal Maximum (Payette, 1984). Besides climate variations, the vegetation dynamics of boreal peatlands can also be affected by fire, but this disturbance is much less frequent in these ecosystems than in upland forests (e.g., Kuhry, 1994; Camill et al., 2009; Magnan et al., 2012).

The main objective of this study is to evaluate the factors that influenced the long-term development of the maritime ombrotrophic peatlands along the St. Lawrence Estuary (Baie-Comeau) and the Gulf of St. Lawrence (Havre-Saint-Pierre). More specifically we aim to 1) document the timing of peatland initiation and the early ecological process of peat accumulation within two edaphic contexts and 2) compare the Holocene development of maritime peatlands from two distinct bioclimatic regions. We hypothesise that the ecological mode of peat inception has been similar in both regions but that the peatlands of Baie-Comeau and Havre-St-Pierre have followed different development pathways over the Holocene.

Methods

Study area and sites

Two of the largest ombrotrophic peatland complexes along the north shore of the Estuary and the Gulf of St. Lawrence were investigated on the Manicouagan delta near Baie-Comeau (BC) and on the La Romaine delta near Havre-St-Pierre (HSP) (Fig. 1). We selected sites with relatively flat basins in order to limit the topographic influence on long-term peatland development (sensu Belyea and Baird, 2006). In each region, peatlands were selected within two geomorphic settings below and above the limit reached by the Laurentian marine transgression (i.e., ~14–16 m above present-day sea level; Bernatchez, 2003). Lebel, Plaine and Romaine peatlands developed over well-drained deltaic sands at elevations ranging between 17 and 31 m asl. Baie, Manic

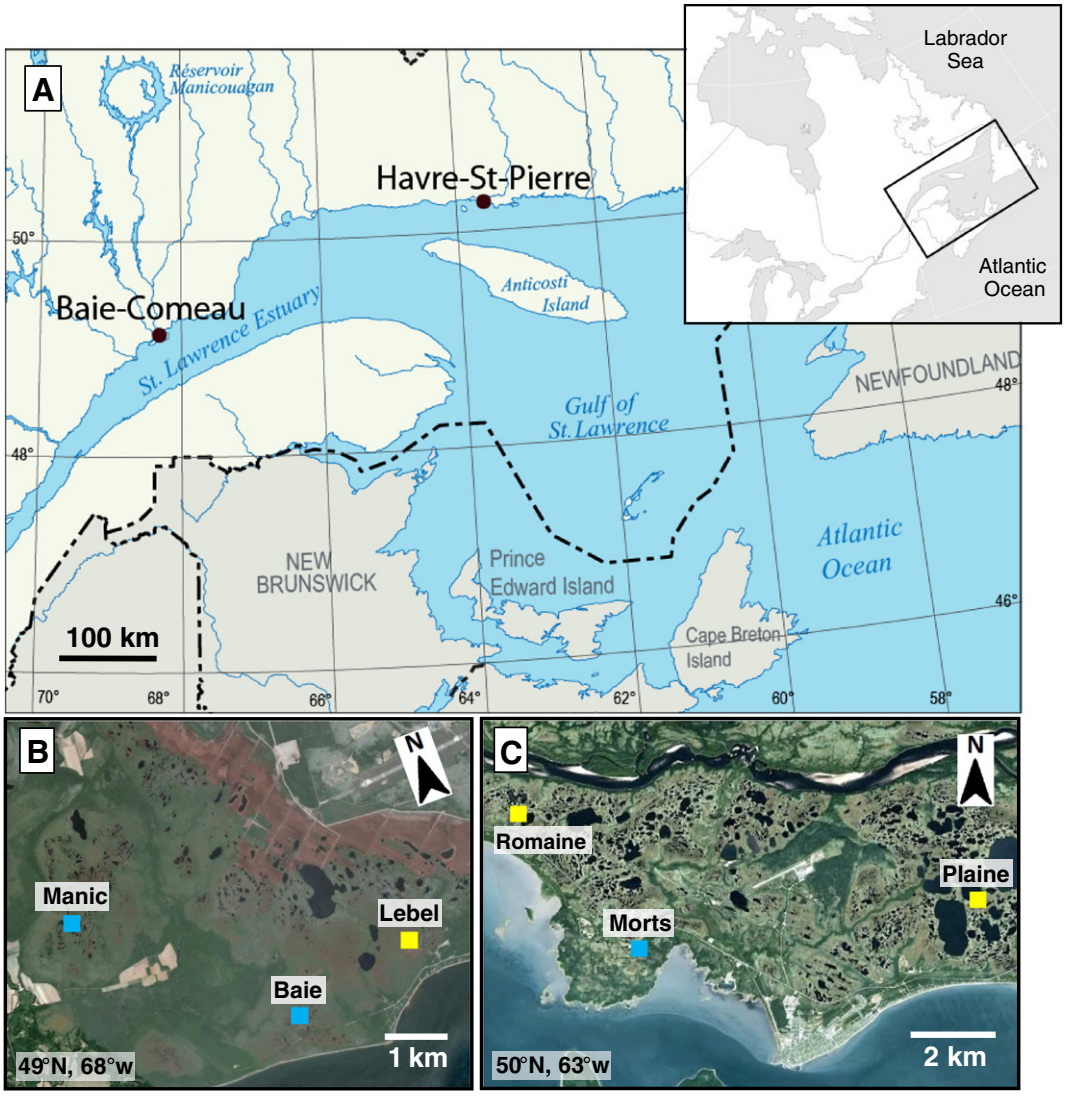

Figure 1. (A) Map showing the two studied regions in eastern Canada and the location of the coring sites in the peatlands investigated on (B) the Manicouagan delta near Baie-Comeau and (C) the La Romaine delta near Havre-St-Pierre. Yellow squares show peatlands on deltaic sands and blue squares represent peatlands above silt–clay deposits. Satellite images from Google Earth 2013.