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Sediment sequences and palynology of outer South Bay, Manitoulin Island, Ontario: Connections to Lake Huron paleohydrologic phases and upstream Lake Agassiz events

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ABSTRACT

South Bay on the southern coast of Manitoulin Island is a fjord-like embayment connected to Lake Huron by a natural narrow gap in the bay's outer sill 6.5–14 m above the lake. A seismic profile, pollen, plant macrofossil, grain size analyses, and other sediment properties of two piston cores from a shallow outer basin of the bay document a 9 m-thick sediment section comprising rhythmically laminated clay under silty clay containing zones with small molluscan shells and marsh detritus. A sandy pebbly layer under soft silty clay mud overlies these sediments. This stratigraphy represents inundation by deep glacial Lake Algonquin followed by the shallowing Post Algonquin series of lakes, and exposure in the early Holocene by 5 Lake Stanley lowstands in the Lake Huron basin separated by 4 Lake Mattawa highstands. Overflow from South Bay in the first lowstand is thought to have eroded the outer sill gap. Marsh environments are inferred to have formed in the bay during subsequent lowstands. The Lake Mattawa highstands are attributed to outburst floods mainly from glacial Lake Agassiz. Palynological evidence of increased spruce occurrence, an apparent regional climate reversal, during the dry pine period is attributed to cold northwest winds from the Lake Superior basin and a lake effect from the Mattawa highstands in the Lake Huron basin. Lake waters transgressed South Bay following the pine period to form the Nipissing shore on Manitoulin Island. Transfer of Lake Huron basin drainage to southern outlets and continued glacioisostatic uplift of the region led to the present configuration of South Bay and Lake Huron.

1. Introduction

South Bay is a 25 km-long by 1- to 5-km wide embayment with fjord morphology on the southern coast of Manitoulin Island in northern Lake Huron, Ontario (Figs. 1a and b). The crest of an outer sill ranges from 6.5 m to 14 m above the present lake, and is breached by a relatively narrow 250 m-wide gap, about 11 m deep, that allows exchanges of South Bay and northern Lake Huron waters at a common mean level of 176 m above present sea level (asl). The embayment consists of a 58 m-deep inner basin and a shallow outer basin up to 13 m deep.

The South Bay embayment is strategically located adjacent to the northern Lake Huron and Georgian Bay basins in the upper Great Lakes region which lies between the overflow outlets of glacial Lake Agassiz and the Lake Superior basin to the west and the early Holocene outlet of the upper Great Lakes at North Bay, Ontario, to Atlantic Ocean via the Ottawa and St. Lawrence river valleys. Thus South Bay is well-positioned to have been sensitive to fluctuations in water level and suspended sediment transport which followed large flows and outburst floods from upstream sources, especially during early Holocene time while giant Lake Agassiz overflowed its eastern outlets through the Superior basin.

Here, we describe the sedimentary and palynological sequences in the outer basin, and the development of the outer sill gap in relation to late Pleistocene and Holocene lake-level changes in the Lake Huron basin, and to other regional events, including glacial Lake Agassiz outburst floods via its eastern outlets. Lake-level changes are explored further to explain a recurrence of spruce vegetation in the Lake Huron basin within the early Holocene pine maximum detected in the pollen record.

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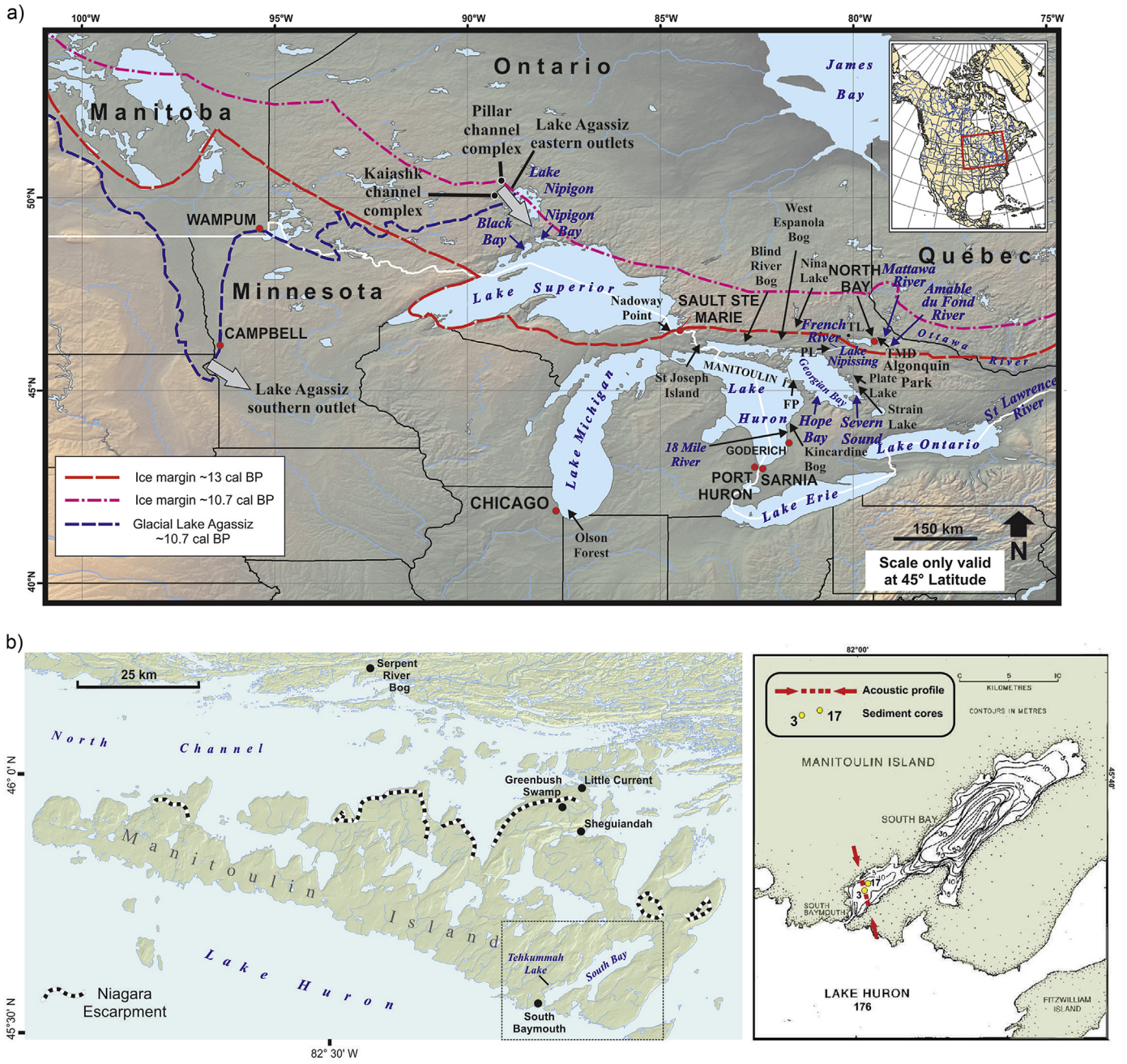

Fig. 1. Location maps. a) Regional map of the Great Lakes area, and part of the Lake Agassiz basin (After Teller and Leverington, 2004). PL = Pure Lake, FP = Flummerfelt Patch, TL = Tanner Lake, and TMD = Trout Mills delta. Approximate locations of Laurentide Ice Sheet southern margins are shown at ~13.0 cal ka BP and ~10.7 cal ka BP (After Dyke and Prest, 1987; Dyke, 2004). Between these dates and by about 11.5 cal ka BP ice had readvanced onto the south shore of the Lake Superior basin again as the Marquette Readvance before retreating northward to open the eastern outlets of Lake Agassiz about 10.7 cal ka BP. b) Manitoulin Island (left), and South Bay (right) showing locations of cores and sub-bottom profile. Area of right figure shown on left figure by dotted black rectangle. Niagara Escarpment on left positioned at the boundary of Lower Silurian and Upper Ordovician rock sequences (Ontario Geological Survey, 1992).

2. Regional setting and background

Manitoulin is the largest island in the Laurentian Great Lakes system of east-central North America and is often referred to as the largest 'freshwater' island in the world (Fig. 1b). Its east–west length is about 120 km and north–south width about 5–50 km, being widest at its eastern end.

The bedrock of Manitoulin Island and northern Lake Huron basin consists of Paleozoic sedimentary formations composed of Upper Ordovician to Middle Silurian carbonate (limestone and dolostone) with some clastic (shale) lithologies. These rocks overlap crystalline rocks of the Precambrian Shield to the north and dip gently south and southwestward into the Michigan structural basin (Johnson et al., 1992). The bedrock surface of Manitoulin Island slopes upward from Lake Huron on its southern coast to elevated cliffs and cuestas, including the Niagara Escarpment (Fig. 1b), on its northern margin which comprise the eroded northern edges of the sedimentary rock units in the region. The Island attains elevations of more than 305 m asl in its northeastern sector (Chapman and Putnam, 1984; Warner et al., 1984).