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Late-stage phases of glacial Lake Ojibway in the central Abitibi region, eastern Canada

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ABSTRACT

The decay of the Laurentide ice sheet southern margin during the last deglaciation led to the development of Lake Ojibway that covered large expanses of northeastern Ontario and northwestern Quebec. The history of Ojibway lake phases is poorly detailed mainly because of the physical configuration of the lake basin and the dominance of fine-grained glaciolacustrine sediments that prevent the formation of well-developed and extensive sandy strandlines. Here we use a complex sequence of relict terraces carved in glaciolacustrine rhythmites to document the evolution of Lake Ojibway in northwestern Quebec. Specifically, lake levels were constrained by measuring the elevation of 154 raised wave-cut scarps present in the eastern Lake Abitibi region. Results provide evidence for four distinct shorelines with elevations of 299, 289, 282, and 272 m (±1 m) at the latitude of La Sarre. The highest lake level documented appears to be linked to one of the two known (Kinojévis) phases of Lake Ojibway, while the three other lake levels project well below the main outlet system that controlled the elevation of the lake during the deglaciation. The elevation, uplift gradients, and areal extent of these lower shorelines suggest that the two intermediate lake levels likely formed during late stages of the deglaciation, following abrupt drawdowns of the lake's surface. The fourth and lowest shoreline is associated with a postglacial lake that developed after the complete withdrawal of Ojibway water from the region. These low-elevation shorelines bring new evidence for significant changes in the areal extent and depth of Lake Ojibway near the end of the deglaciation. Although the origin of these late-stage phases remains unspecified, the associated drawdowns likely implied routing events into newly deglaciated regions and/or (subglacial) meltwater discharges into the North Atlantic.

1. Introduction

Meltwater released at the southern margin of the Laurentide ice sheet (LIS) in central and eastern North America during the last deglaciation led to the development of large glacial lakes such as Lake Agassiz and Lake Barlow–Ojibway (Fig. 1A,B). The evolution of these proglacial lakes was intimately linked to the configuration and dynamics of the decaying ice margin (e.g., Dyke, 2004). The continued northward ice retreat liberated outlets, causing the lakes to expand and/or to be routed into newly deglaciated basins. This pattern of ice withdrawal was interrupted in places by significant ice readvances that momentarily modified the basin geometry. Lake levels were generally controlled by the position of the ice margin with respect to outlets but also fluctuated in response to changes in outlet elevation caused by spillway erosion and glacial isostatic adjustment of the terrain. As a result, the history of the lakes is recorded by a complex sequence of shorelines that shows an overall lowering (regression) of the lake levels, which was marked by abrupt drops that were generally followed by rises (transgressions). This evolution is particularly well documented in the Lake Agassiz basin where over a century of research has identified several lake stages, along with the position of outlets and the occurrence routing events (Upham, 1895; Johnston, 1946; Elson, 1967; Teller et al., 1983; Smith and Fisher, 1993; Lewis et al., 1994, 2005; Thorleifson, 1996; Teller and Leverington, 2004; Fisher et al., 2009). Reconstructions of Agassiz lake levels are based for the most part on a series of extensive shorelines that spread over large areas of the flat-laying prairie terrain that was covered by the lake. This contrasts markedly with Lake Barlow–Ojibway that flooded the gently rolling terrain of the Precambrian Shield where the distribution of shorelines is sporadic and difficult of access because of the dense forest cover. Accordingly, the evolution of Lake Ojibway remains inadequately documented, being essentially restricted to three phases that mark the maximum levels reached by the lake (Vincent and Hardy, 1979; Veillette, 1988, 1994).

The lack of finer resolution on Ojibway lake phases is related to the scarcity of shorelines, as well as the physical characteristics of this glaciolacustrine basin. The Abitibi region, the area covered by a large portion of Lake Ojibway, is characterized by an overall subdued topography, consisting of vast expanses of rolling clay plain that are broken in places by rare and isolated bedrock knobs (hills) — a physical setting that prevents high and intermediate lake levels to be recorded widespread throughout the area. The predominance of fine-grained

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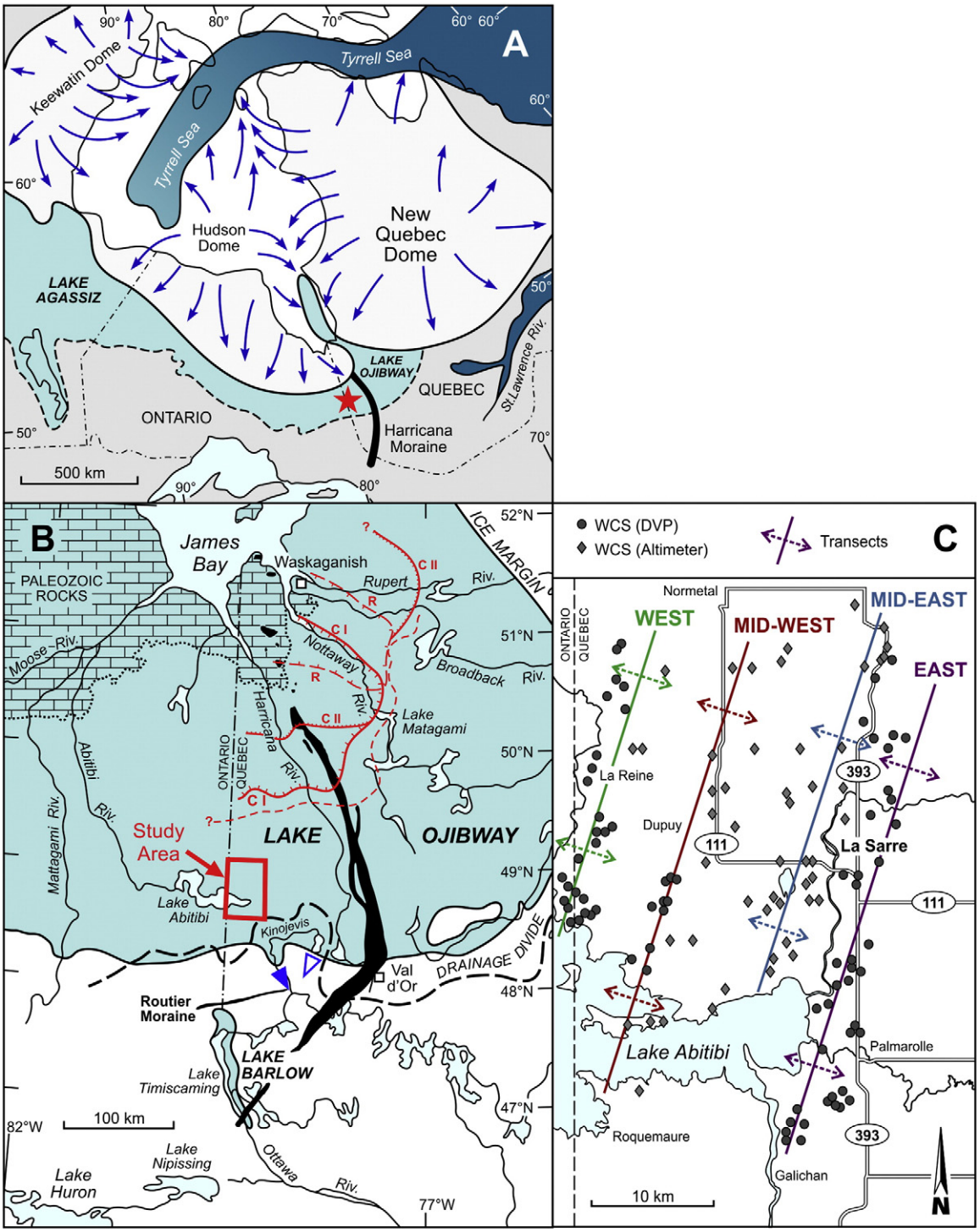

Fig. 1. (A) Location of the study area (red star) with respect to the Laurentide ice sheet and Lake Ojibway during the deglaciation at ~7.8 cal yr BP (ice margin from Dyke, 2004). (B) The eastern Lake Abitibi region and the main geomorphic features in the area submerged by Lake Ojibway. Red lines delineate the extent of the late glacial ice readvances: C1—Cochrane I, R—Rupert, C2—Cochrane 2 (after Hardy, 1977; Veillette, 1994). Triangles show the location of the outlet for the early (solid) and late (open) Kinojévis phases (after Vincent and Hardy, 1979). (C) Location of the wave-cut scarps (WCS) studied around La Sarre. The elevation of WCS was measured with a Digital Video Plotter (DVP) software package (circle) and altimeters (diamonds). The long lines show the position of the transects used to analyze the data (see text for details).

glaciolacustrine sediments also does not favor the development of the typical coarse-grained (sandy, gravelly) shorelines and associated nearshore deposits that are generally used to study the history of lake levels. The known high-elevation lake phases of Lake Ojibway were documented either from discontinuous boulder beaches that developed on thick till deposits covering hills that stood as islands in the lake, or from wave-washed annular bedrock bands on such hills that mark the erosive action of those high lake surfaces (e.g., Veillette, 1994).

Accordingly, constructional shorelines and associated deposits are extremely rare at the level of the vast Ojibway clay plain, which surface elevation rarely exceeds 310–320 m asl (meters above sea level; thereafter all elevations are in m asl). A notable exception is the region