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New insights on the late-stage history of glacial Lake Ojibway: implications for meltwater discharges of the last deglaciation

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The decay of the Laurentide ice sheet is believed to be responsible for abrupt climate variations during the last deglaciation and early Holocene, notably through massive discharges of meltwater that had accumulated in large ice-dammed lakes such as Lake Agassiz and Lake Ojibway. Indeed, high-resolution North Atlantic marine records indicate that the ocean's circulation was affected by several outbursts of meltwater during the late deglacial interval. Yet, field evidence and geological data supporting multi-step drawdowns of Lake Agassiz-Ojibway are relatively limited, underlying important uncertainties in the late-stage history of these glacial lakes. Furthermore, physical evidence for the drainage of glacial lakes remains relatively rare in depositional records, giving rise to much debate on the location of outlets and discharge pathways, as well as on the climate impact of the attendant meltwater forcing. Recent investigations of geomorphological and sedimentary records in northern Ontario and Quebec (Canada) have revealed new insights on the late-stage evolution of Lake Ojibway. The number of Ojibway lake phases have so far remained poorly documented mainly because of the dominance of fine-grained glaciolacustrine sediments in the lake basin that prevented the formation of extensive sandy/bouldery strandlines. We thus developed an alternative approach based on the study of a complex sequence of relict terraces carved in the Ojibway clay plain. The elevation measurement of 154 raised wave-cut scarps provided evidence for four distinct shorelines, three of which projecting well below the main outlet that controlled the elevation of the lake during the deglaciation. The elevation, uplift gradients, and areal extent of these shorelines indicate that these low-elevation lake levels formed during the late stages of the deglaciation, following abrupt drawdowns of the lake's surface. Insights on the origin of these late-stage phases are provided from sediment sequences located east of James Bay that preserve a well-developed drainage unit. There, the microfossil content and associated stable isotope geochemistry of the underlying Ojibway rhythmites indicate that the final drawdown of the lake was preceded by episodic subglacial drainage events. Radiocarbon dating of the sequence has also refined the timing of the final lake drainage. This event is also present deeper within the southeastern Ojibway basin where the grain size and geochemical composition of thinly bedded rhythmites, as well as the oxygen isotope of ostacods, document an anomalously thick and coarse-grained marker bed that records the abrupt termination of the lake in this region. Taken together, these results indicate that the late-stage history of Lake Ojibway was marked by significant changes in the areal extent and depth of the lake, which likely implied routing events into newly deglaciated regions and/or (subglacial) meltwater discharges into the North Atlantic. Our investigations also identify the James Bay region as a major drainage pathway for meltwater at the end of the last deglaciation. The elevation, extent and chronology of the Ojibway shoreline sequence are currently being refined in order to improve paleogeographic reconstructions and estimates of meltwater volumes, all aspects that are critically needed to evaluate the impact of freshwater discharges on ocean circulation.