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Reconstructing the lake-level history of former glacial lakes through the study of relict wave-cut terraces: the case of Lake Ojibway (eastern Canada)

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The reconstruction of the history of former glacial lakes is commonly based on the study of strandlines that generally consist of boulder ridges, sandy beaches and other near-shore deposits. This approach, however, is limited in some regions where the surficial geology consists of thick accumulation of fine-grained glaciolacustrine sediments that mask most deglacial landforms. This situation is particularly relevant to the study of Lake Ojibway, a large proglacial lake that developed in northern Ontario and Quebec following the retreat of the southern Laurentide ice sheet margin during the last deglaciation. The history of Ojibway lake levels remains poorly known, mainly due to the fact that this lake occupied a deep and featureless basin that favored the sedimentation of thick sequences of rhythmites and prevented the formation of well-developed strandlines. Nonetheless, detailed mapping revealed a complex sequence of discontinuous small-scale cliffs that are scattered over the flat-lying Ojibway clay plain. These terrace-like features range in size from 4 to 7 m in height and can be followed for 10 to 100's of meters. These small-scale geomorphic features are interpreted to represent raised shorelines that were cut into glaciolacustrine sediments by lakeshore erosional processes (i.e. wave action). These so-called wave-cut scarps (WCS) occur at elevations ranging from 3 to 30 m above the present level of Lake Abitibi (267 m), one of the lowest landmarks in the area. Here we evaluate the feasibility of using this type of relict shorelines to constrain the evolution of Ojibway lake levels. For this purpose, a series of WCS were measured along four transects of about 40 km in length in the Lake Abitibi region. The absolute elevation of 154 WCS was determined with a Digital Video Plotter software package using 1:15K air-photos, coupled with precise measurements of control points, which were measured with a high-precision Global Navigation Satellite System tied up to known geodesic survey markers. Additional WCS were also measured with altimeters. The results suggest that Lake Ojibway experienced at least three different phases, at elevations of 283 m, 289 m, and 300 m (precision $\pm$ 0.5 m). For comparison, the near-maximum phase of Lake Ojibway (the only known phase) that was documented about 250 km to the NE would project at an elevation of about 385 m in the study area. Taken together, the position of these WCS in the landscape, their elevation and associated uplift gradients suggest that these lake levels were formed during episodes of long stands associated with late-stage phases of glacial Lake Ojibway. Overall, these results underlie the strong potential of the use of relict and discontinuous wave-cut terraces to reconstruct the lake-level history of former glacial lakes. This approach could also contribute to derive new estimates of meltwater volumes, a critical parameter in evaluating the impact of meltwater discharges on the late-glacial and deglacial climate.