

Timing and paleogeographic reconstruction of glacial Lake Low in western Labrador

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Summary

The timing and configuration of retreating ice margins are important to understanding the demise of past ice sheets, and glacial lakes are a key component of this reconstruction (Jansson, 2003; Dyke, 2004). Glacial Lake Low was a previously unidentified proglacial lake of the Laurentide Ice Sheet that formed north of the headwaters of the Churchill River, in lowlands now occupied by the Smallwood Reservoir in Labrador. Glacial Lake Low formed within a re-entrant into the retreating ice sheet in the Churchill River valley, constrained by a low elevation drainage divide with its outlet at the Churchill River. This glacial lake occupied a basin south of the modern drainage divide along the Quebec and Newfoundland and Labrador border. This lake was named after Albert P. Low (1861–1942) of the Geological Survey of Canada, who first recognized in the 1890s that the final disintegration of the continental ice sheet occurred generally in this region (Low, 1896).

Although relatively shallow, glacial Lake Low formed extensive beach ridges that were identified through surficial mapping which indicates the maximum washing limit of the lake was ~ 485 m asl (above sea level). The glacial lake drained following minor isostatic rebounding that resulted in the drainage divide between the Arctic and Atlantic oceans migrating northwest, allowing meltwater to flow south into the Churchill River valley. Waters then ponded in the former basins of Ossokmanuan, Lobstick, and Michikamau lakes, which were merged by the construction of the Smallwood Reservoir, created in 1974 with the damming of the Churchill River at Churchill Falls.

Methods

Surficial mapping was conducted using black and white aerial photographs (approximately 1:60 000 scale) flown before (1951) the Smallwood Reservoir was flooded (1975) for hydroelectric use and aerial photos flown afterwards (1981) to allow for a more accurate representation of the surficial units. Field verification of mapped surficial units was completed at selected locations over the course of three field seasons (2014-2016); samples were also collected for geochronology in order to constrain the timing of lake formation.

Two samples (14-PTA-R035 and 14-PTA-R036) were collected for optical dating from littoral beach sediments associated with glacial Lake Low. Samples were collected from natural exposures located on a small island located within the Smallwood Reservoir. Fine sands were collected from littoral beach sediments following procedures of Aitken (1998) and Lian (2013) and submitted to the Luminescence Dating Laboratory at the University of the Fraser Valley, Abbotsford, British Columbia for optical dating. Optical dating sample 14-PTA-R035 was collected from an elevation of 464 ± 5 m (asl) and sample 14-PTA-R036 was collected from the same beach exposure, one meter below sample 14-PTA-R035.

Results

Surficial mapping identified 637 beach ridges associated with two levels of glacial Lake Low (Paulen et al. 2017, 2019a, 2019b). The sediments in the beach ridges are typically characterized by pebbly to coarse granular sand that is moderate- to well-sorted with stratification and sometimes with an open framework of clasts in the coarser units. These beach ridges are restricted to the general basin of the Smallwood Reservoir, with a high concentration in the Knox lake region in the upper western arm of the lowland area. Eskers within the region crosscut the former lake basin, and there is no evidence of subaqueous fan or delta deposits. This suggests that eskers formed before glacial lake development and indicates that significant subglacial meltwater flux had occurred prior to the formation of glacial Lake Low.

Feldspar grains from the two collected raised beach samples yielded contrasting optical dating results. Sample 14-PTA-R036 yielded an anomalously old age of 129.5 ± 21.2 ka, which suggests insufficient bleaching of the grains prior to deposition. However, results from sample 14-PTA-R035 yielded an age of 9.8 ± 0.6 ka (possibly as young as 8.6 ka with the analytical uncertainty taken into account at two standard deviations). This age either requires the lake basin to be ice free about 1 to 2 ka earlier than is suggested by previous ice margin retreat reconstructions (Dyke, 2004; Ullman et al., 2016), or it also suffers, to some degree, from partial bleaching.

A re-entrant in the ice sheet extending from the Churchill River valley into the lowlands, now occupied by the Smallwood Reservoir, would explain both the occurrence of an ice-free basin hosting glacial Lake Low, and the required ice dam in the bedrock valleys to the east. This opening in the ice sheet may have been facilitated by late phase ice streams and by the large esker network that formed in this basin, which would have enhanced ice sheet drainage and thus thinned the ice sheet considerably (Occhietti et al., 2004). Glacial Lake Low formed, and subsequently drained, prior to the westward retreat of the Laurentide Ice Sheet over the bedrock highlands to the north, where the earliest phases of glacial Lake Naskaupi formed at a later time (Rice et al., 2019).

Despite uncertainties regarding the degree of bleaching of the luminescence signal of sand grains in our sample, the result provide a realistic and plausible reconstruction, especially when put within the broader topographic and drainage context, the surficial geology and the available age constraints in the surrounding region. Future work should involve detailed sedimentological analysis in combination with additional optical dating of the coarse beach deposits. New techniques, such as luminescence dating of cobbles in glacial sediments (Jenkins et al., 2018; Duller et al., 2019) may also be a promising avenue for dating coarse beach deposits.

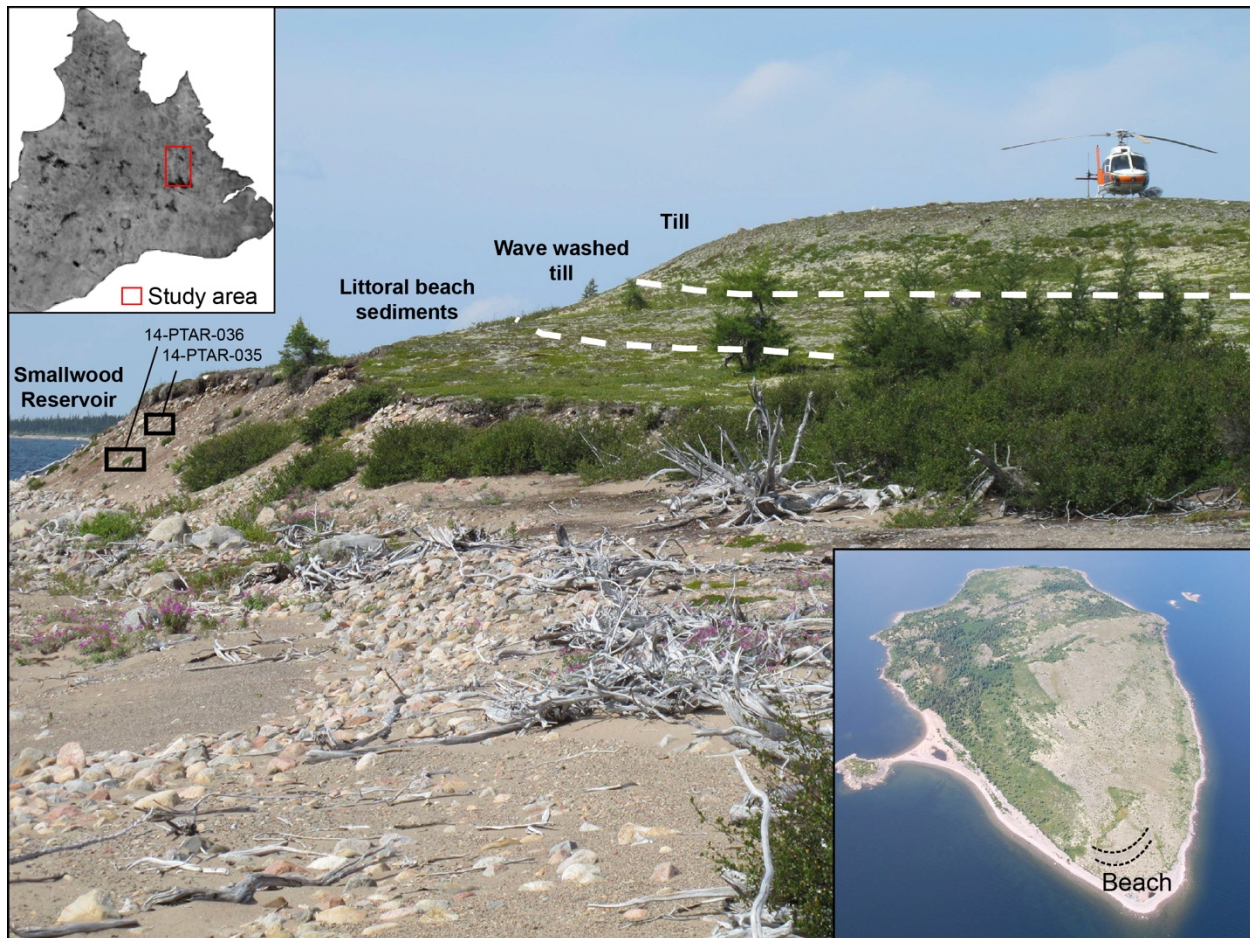


Figure 1. Beach sediments of glacial Lake Low exposed from wave action of the modern Smallwood Reservoir. Samples were collected from this exposure of littoral sediments for chronology.

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