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Authors’ addresses

L.A. Dredge (ldredge@nrcan.gc.ca)
I. McMartin (imcmarti@nrcan.gc.ca)
Terrain Sciences Division
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

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Glacial lakes in the Wager Bay area, Kivalliq, Nunavut

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Abstract : Evidence of several types of glacial lakes is present in the Wager Bay map area. Glacial lakes in the southern half of the map area were small features related to temporary blockage of meltwater by plugs of till or kame. Glacial lakes farther north were more extensive and ice dammed. The largest was an expansion of Brown Lake, marked by large inflow deltas and a sequence of wave-cut notches, whereas finger lakes with deeply incised spillways developed in upland valleys south of Ford Lake. Lake levels fell as successively lower outlets were exposed by the receding ice front. The extent and configuration of the northern lakes require an ice front retreating southeast across Brown Lake as far as the west end of Ford Lake; this ice margin must have formed the west side of a late ice divide. The finger lakes formed subsequently on the eastern side of the ice divide, as a marine calving bay moved west up Wager Bay.

Résumé : Des indices de la présence de plusieurs types de lacs glaciaires se rencontrent dans la région de la baie Wager. Les lacs glaciaires dans la moitié sud de la région étaient de petites étendues d'eau de fonte barrées temporairement par des bouchons de till ou de kame. Plus loin au nord, les lacs étaient plus étendus et barrés par la glace. Le plus vaste d'entre eux était un élargissement du lac Brown, décelé par la présence de vastes deltas d'affluents et d'une succession d'encoches créées par les vagues. Des lacs digités aux déversoirs profondément encaissés se sont formés dans les vallées des hautes terres au sud du lac Ford. Les niveaux lacustres ont baissé au fur et à mesure que des exutoires moins élevés ont été exposés par le retrait du front glaciaire. L'étendue et la configuration des lacs dans le nord de la région s'expliquent par le retrait du front glaciaire vers le sud-est, au-delà du lac Brown et jusqu'à l'extrémité ouest du lac Ford; cette marge glaciaire aurait formé le côté ouest d'une ligne de partage tardiglaciaire. Les lacs digités se sont formés par la suite du côté est de la ligne de partage glaciaire, au fur et à mesure qu'une baie de vêlage marine progressait vers l'ouest dans la baie Wager.

INTRODUCTION

The first measurements on high-level strandlines in the Wager Bay area resulted from field work by Bird (1954), who observed that postglacial marine or lacustrine water surfaces there reached heights of between 110 and 122 m above sea level (a.s.l.). Bird (1967) later concluded that higher trimlines were related to glacial lakes and that they reached heights of 168 m in the southwest part of Wager Bay, and 122 to 137 m and 247 m north of Ford Lake to the west. The glacial map of Canada (Prest et al., 1967) shows all these levels to be marine.

This study presents new measurements on glacial lake levels in the Wager Bay map sheet (NTS 56 G), which includes the head of Wager Bay, Ford Lake (elevation 1 m a.s.l.), and Brown Lake (elevation 34 m) (Fig. 1). Although lowland areas lie along the north shore of Brown Lake, uplands rise abruptly from the three water bodies along their southern edges. The highest terrain reaches 578 m in elevation, and separates rivers flowing northward into Wager Bay from those draining southward to Chesterfield Inlet and Hudson Bay. The drainage divide lies about 20 km south of Brown Lake and Wager Bay: this area also served as an ice divide during the last glaciation (McMartin and Dredge, 2005). A second drainage divide, separating rivers draining south into Wager Bay from those draining northward into the Arctic Ocean, lies roughly 60 km north of Ford Lake, beyond the study area.

Two main types of glacial lakes are described in this report. The first are proglacial lakes, where sediment-laden meltwater, flowing down the natural slope of the land, was obstructed by till or kame dams. The second are ice-marginal lakes, where water bodies were trapped between

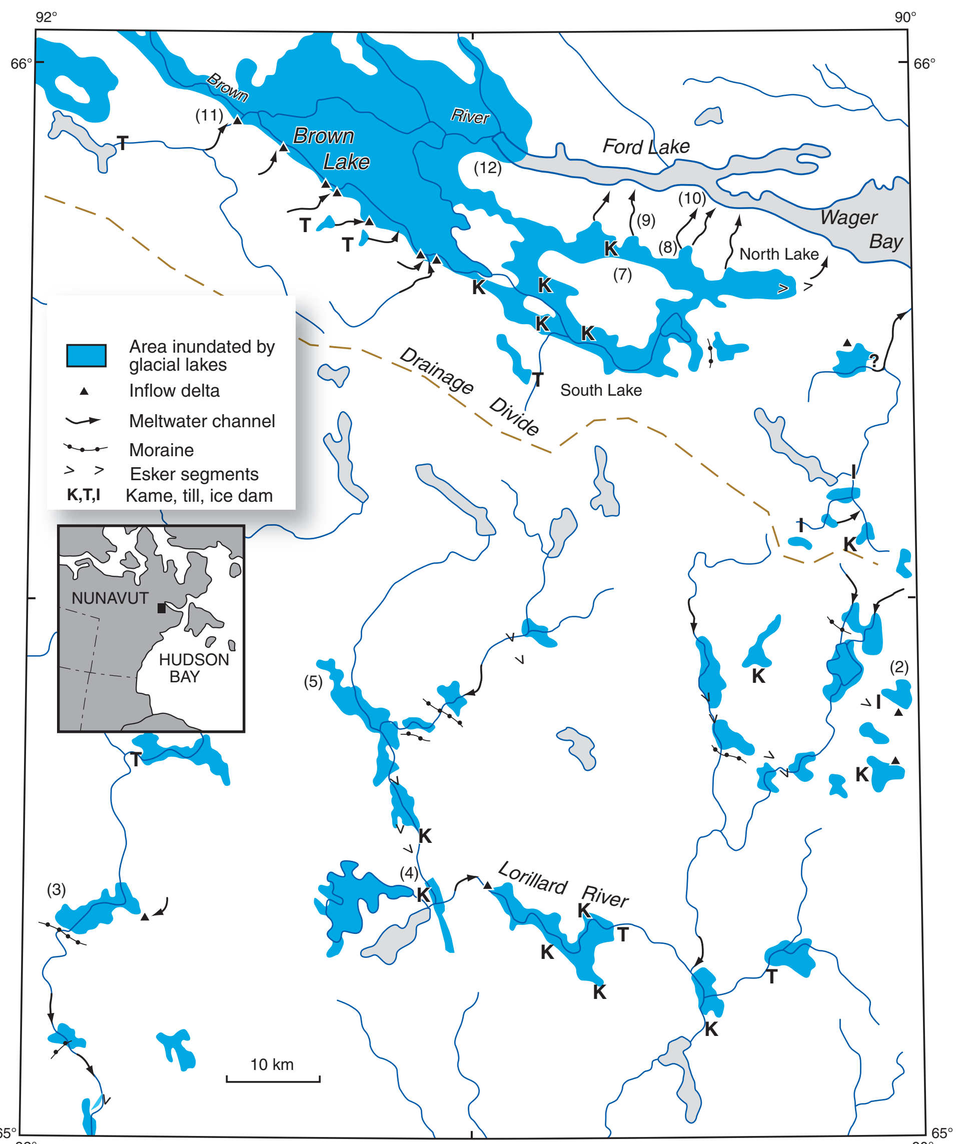

Figure 1. *Location of glacial lakes in the Wager Bay area. Numbers in brackets show locations of photos.*

a major ice margin and the hillsides. The two types of lakes differ not only in size and situation, but also in character. This paper summarizes the main characteristics of each type.

PROGLACIAL LAKES SOUTH OF THE UPLANDS AND DRAINAGE DIVIDE

South of the main drainage divide (Fig. 1), there is evidence of only one, relatively small glacial lake that formed where an ice front blocked natural drainage (Fig. 1 and 2). For the remainder of the area, meltwater from the northward-receding ice margin coursed southward down the regional slope of the land, unimpeded by glacial ice or major topographic obstructions. Eskers and subparallel proglacial outwash trains are major landforms that reflect the late glacial drainage pattern. Like the modern rivers, the outwash trains flow generally southward but have east-west reaches, and it is in these east-west portions that glacial lakes are most common. The lakes have developed where drainage southward has been impeded and diverted by moraines, kames, and plugs of till; the various debris-dammed lakes probably drained as soon as the obstructions were breached (Fig. 3). In a few places, lakes also developed where the terrain gradient may have been too low to handle high amounts of meltwater discharge. Lakes created in this way are essentially expansions of proglacial outwash channels.

The lakes south of the uplands and shown on Figure 1 are all small features. Their lakebeds are covered with deposits of medium-grained sand 1 to 3 m thick (Fig. 4). The main topographic expressions of the lakes are flat surfaces slightly above modern rivers, covered with grasses and circular tundra ponds (Fig. 3 and 5). Where lakes have expanded beyond outwash plains onto surrounding till surfaces, their shorelines are marked by poorly defined notches, and the blanket of glaciolacustrine sand overlies till rather than outwash. The blanketed till commonly has a striped (rilled) appearance on airphotos. Normal braided outwash channels form the inflows and outflows of most of the lakes, although small deltas are present in some places.

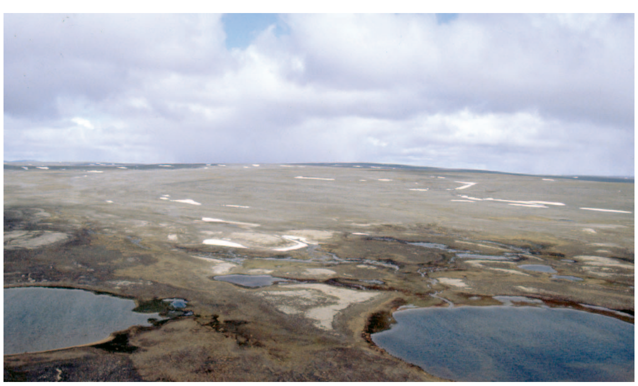

Figure 2. *Delta at 405 m and lake-basin deposits created where drainage was blocked by an ice margin on the south side of the ice divide. Ice-marginal channels rise up the bare hill slope in the background. Photograph by L. Dredge.*

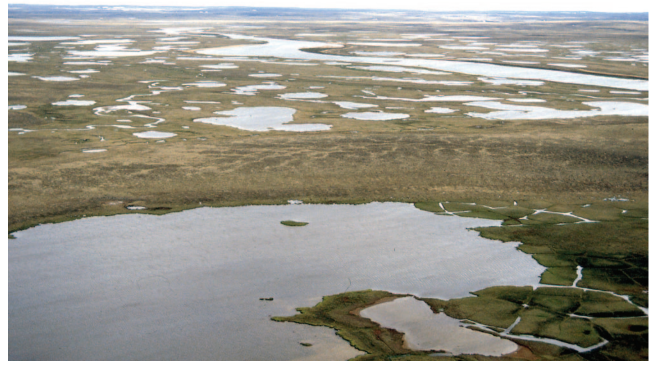

Figure 3. *Tundra ponds on glaciolacustrine sand. The moraine ridge across the foreground temporarily impeded meltwater flow. Photograph by L. Dredge.*

Figure 4. *Ground view of glaciolacustrine sand at Dunsmuir Resources camp. Photograph by L. Dredge.*

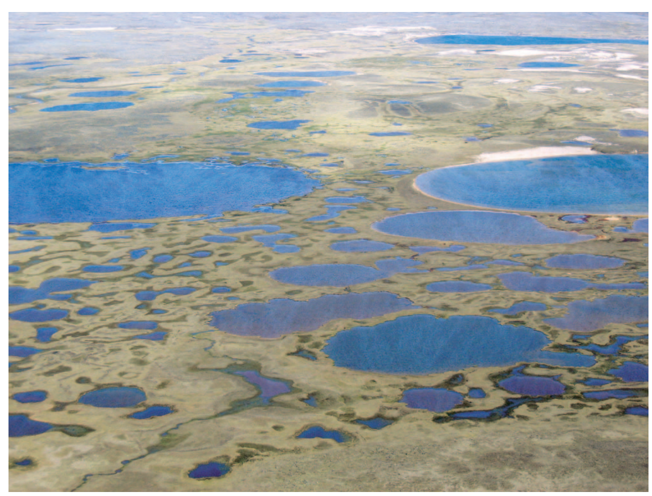

Figure 5. *Tundra ponds, grass-covered surfaces, and bare areas of sand characterize proglacial lake basins along the Lorillard River. Photograph by J-F Gagnon.*

Narrow, elongated sand bodies flanking some of the eskers, such as those along the Lorillard River, were probably deposited in subglacial lakes, where either kame deposits or low drainage gradients caused water to back up. Such lakes are too small to show on Figure 1.

CHARACTERISTICS AND HISTORY OF ICE-MARGINAL GLACIAL LAKES NORTH OF THE DRAINAGE DIVIDE

Two glacial finger lakes (North Lake and South Lake on Fig. 1), each up to 30 km long, occupy east-west trending valleys that presently drain westward into Brown Lake (Fig. 6). These lakes were dammed by late glacial ice tongues retreating down valley. Lacustrine deposits are scarce, although the grassy vegetation occupying lake-basin areas suggests that some deposits are present. Several types of landforms are associated with the lakes. Sets of sublacustrine (crossvalley) moraines are found in both lake basins (Fig. 6). These, together with marginal channels parallel to the ice front and minor ice-contact deltas indicate a westward pattern of ice recession in the valleys. Small sandy pads are common features where small meltwater streams emptied into the lakes from deglaciated terrain, particularly where meltwater from late ice in the highlands to the south drained into South Lake. Wave-cut trimlines are traceable along the sides of the valleys and record a series of lake levels ranging from 320 to 120 m a.s.l. (Fig. 7). Individual trimlines end in spillways whose spill points decline in elevation toward the west. Those related to North Lake emptied into a high postglacial sea, forming deltas that decline in elevation from 106 m in the east to about 97 m in the west.

Small glacial lakes are present at elevations of 420, 380, and 280 m around South Lake, as shown on Figure 6. An early extensive ice-marginal lake formed at 350 m at the eastern end of North Lake and drained through spillway A (Fig. 6) after ice had receded sufficiently to the west to expose the outlet. This and other spillways associated with North Lake have cut deep gorges through rocky uplands. With further recession of the ice margin, lake levels fell to 320 m and then to 260 m using spillway B (Fig. 8). North Lake subsequently fell to 240 m; it may have drained either through outlet C or, more likely, since the trimline does not extend as far west as that outlet, by breaking through the esker and kame debris that had blocked the eastern part of the lake basin. Once the ice front had retreated to near outlet C, the north lake drained from 240 m to 210 m, and then to about (180 or 190 m using outlet D (Fig. 9). During this phase, the 240 m level of South Lake, previously held up by esker debris, spilled over into the northern lake. As ice receded behind the kame moraine near the western end of South Lake, the remnants of North and South lakes may have coalesced at a level of about 170 m. The spillway for this lake level is outlet E. As the ice receded past outlet E, lake levels fell firstly to about 150 m and then to 120 m as spillway F was eroded down. This spillway, like the others related to higher levels of the finger lakes, ends in a delta at marine limit (Fig. 10). Water levels at 120 m lie at the westernmost extremities of the finger lakes and may have initially shared a secondary outlet (G) with the 120 m glacial phase of Brown Lake.

Late ice remaining near the western extremity of former South Lake dammed a small remnant lake that eventually drained to a marine limit at 80 m.

CHARACTERISTICS AND HISTORY OF GLACIAL LAKES NORTH OF THE DRAINAGE DIVIDE OVER BROWN LAKE (GLACIAL LAKE BROWN)

The highest lacustrine landforms in the Brown Lake area are a set of small, sublacustrine (DeGeer) moraines lying at elevations of 260 to 280 m in the northwestern extremity of the map area (Fig. 6). The location and orientation of these features indicate the presence of an early, fairly small glacial lake that was dammed against ice retreating southward across Brown Lake. When the lake existed, the ice margin blocked normal downslope drainage into the lake basin.

Evidence exists of larger lakes that occupied areas around Brown Lake, although glaciolacustrine deposits are scarce. The most notable landforms associated with these lakes are perched gravel deltas located on the southern cliffed shore of Brown Lake at elevations of 164 m (160–170 m), 150 m, 130 or 140 m, and about 120 m. (Fig. 11). In contrast, the marine limit lies at about 95 m, as evidenced by consistent beach deposits at that level, and Brown Lake presently lies at an elevation of 34 m. The high-level glacial lake deltas formed where short proglacial meltwater channels from valley ice tongues emptied into the lake. To produce these, the main ice margin must have been near the south shore of Brown Lake and receding upslope (southward) into the highland area of the modern drainage divide.

On the north side of Brown Lake and up to 10 km inland from the present shore are a series of wave-cut notches incised into the till surface, together with a sporadic veneer of sorted sand overlying some drumlinoid forms. The notches lie at elevations from 180 m down to 110 m, as shown in Figure 6. Although these shorelines may define the northern shores of the glacial lakes that created the deltas south of Brown Lake, it is possible that they relate to slightly earlier ice-marginal positions, when ice still lay in Brown Lake basin: no single lake level is traceable across the whole area, so the glacial lake may have expanded progressively, with retreat of an ice margin towards the southeast. It is notable that the wave-cut notches end abruptly at the western end of Ford Lake and that the direction of ice-marginal retreat is opposite to that which created North Lake and South Lake.

The ice configuration responsible for Glacial Lake Brown is uncertain. The ice-flow sequence determined by the striation record (McMartin and Dredge, 2005) suggests late ice flowing northeastward across Ford Lake and Wager Bay, with a subsequent flow into the bay from the north and south as the ice front calved into an encroaching sea. Either of these flows could have dammed the lake by blocking drainage through

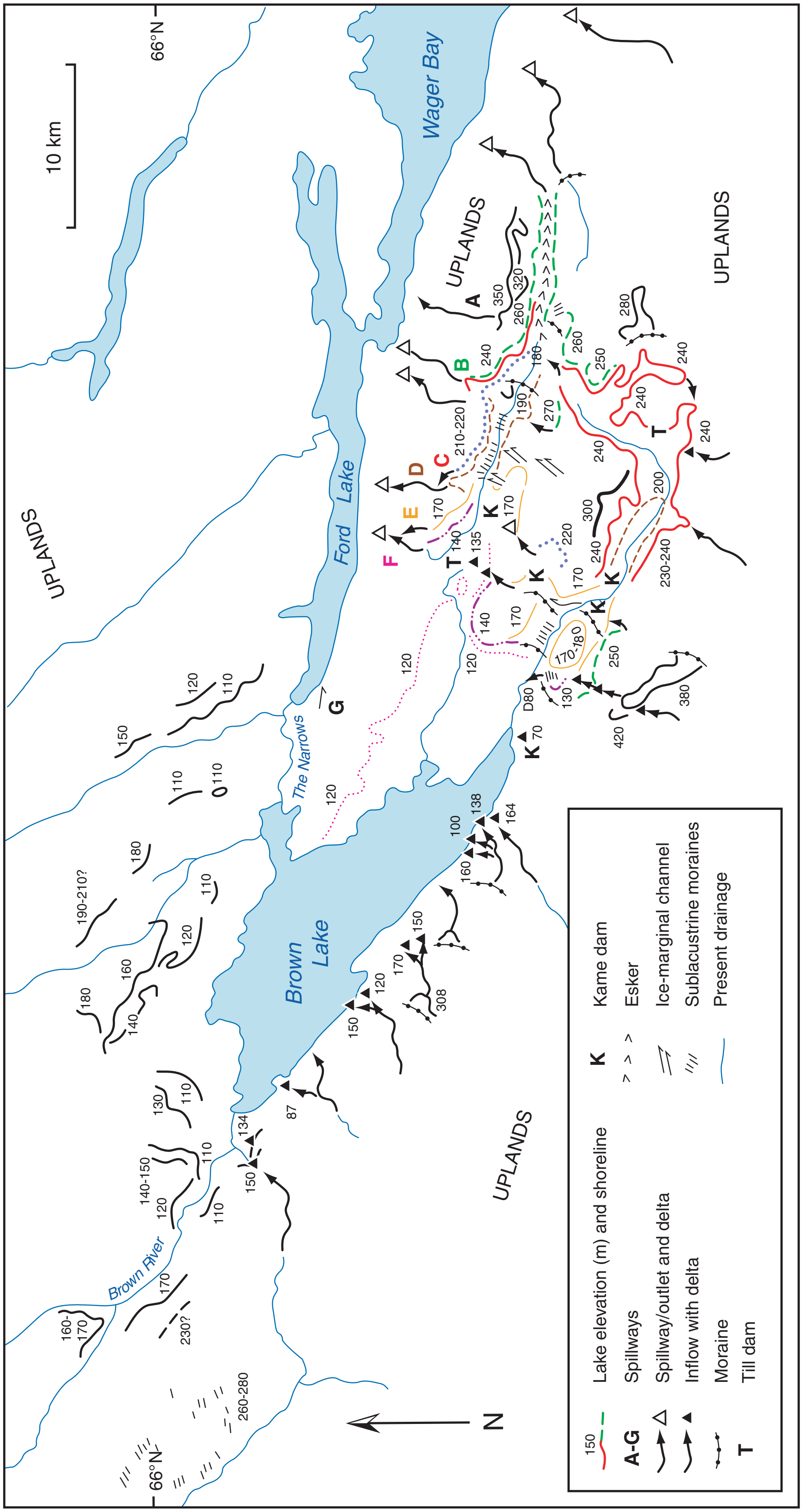

Figure 6. *Glacial lake levels, inflows, and spillways north of the ice divide.*

Figure 7. *Wave-cut trimlines (arrows) on both sides of the north valley record a glacial lake level. Photograph by I. McMartin.*

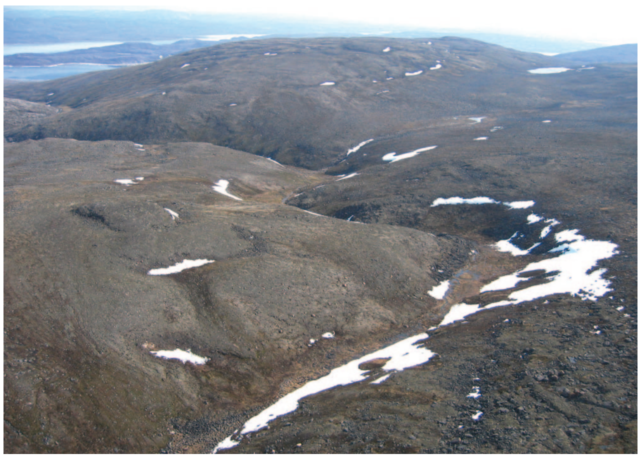

Figure 8. *Spillway outlet B, draining North Lake to 260 m. Photograph by I. McMartin.*

Figure 9. *A gorge 90 m deep forms the spillway outlet for the 210 m level (Outlet C, far right) and 180 m level (outlet D) of North Lake. View downstream toward Ford Lake. Photograph by L. Dredge.*

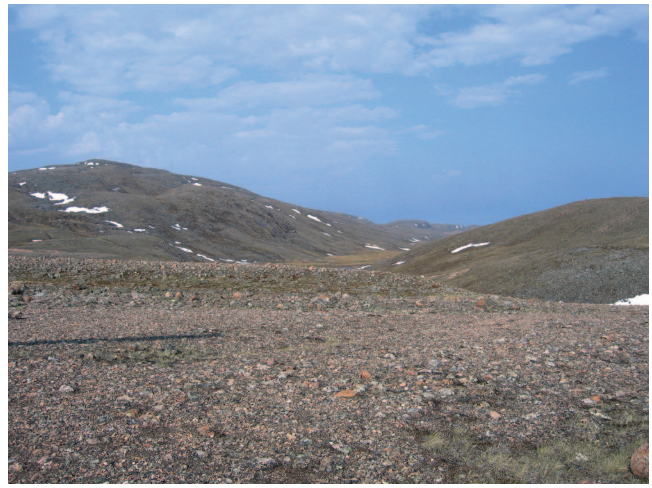

Figure 10. *Looking upstream through spillway B from the gravel delta at marine limit (106 m). Photograph by I. McMartin.*

Figure 11. *Deltas (arrows) at 150 m and 134 m mark meltwater inflows and declining water levels in Glacial Lake Brown. Photograph by L. Dredge.*

Figure 12. *Ice-marginal channels draining the final stages of Glacial Lake Brown. Photograph by L. Dredge.*

the narrows at the west end of Ford Lake (Fig. 6). The abrupt end of glacial lake features along the northwest side of Ford Lake and ice-contact meltwater channels on the south side of the narrows between Brown Lake and Ford Lake are supporting geomorphic evidence for a late ice margin across the narrows. As mentioned above, ice may have been present in the Brown Lake basin during some of the lake phases.

Small outlet channels (Fig. 12) in front of the ice margin that lay at the narrows (outlet G on Fig. 6) would account for partial draining of the lake from its highest levels down to 120 m. A major, deeply incised glacial lake outlet lies about 12 km farther east (F). It drained the 150 and 120 m levels of North Lake and South Lake; however, it is not known whether these lakes were connected to the one in the Brown Lake area at the time.

SUMMARY AND CONCLUSIONS

Several types of glacial lakes associated with deglaciation are present in the Wager Bay map area. Lakes south of the ice divide and present drainage divide are small, sandy-bottomed, short-lived features related to the temporary blockage of southward drainage along meltwater streams by plugs of till or kame. Glacial lakes north of the drainage divide differ from the southern lakes not only in size and situation, but also in character. Those north of the divide are more extensive and were created by blockage of normal drainage by glacial ice. One was an expansion of Brown Lake and is marked by large inflow deltas on the south side of Brown Lake and a sequence of wave-cut notches north of the lake, 10 to 15 km beyond the present shore. Finger lakes developed in upland valleys south of Ford Lake; the main features associated with them are deeply incised spillways flowing from the glacial lakes down to the marine limit. Lake levels fell as successively lower outlets were exposed by the receding ice front. The existence and configuration of the northern lakes require an ice front retreating southeast across Brown Lake as far as the west end of Ford Lake; this ice margin must have formed the west side of a late ice divide. North and South lakes formed subsequently on the eastern side of the ice divide as a marine calving bay moved rapidly up Wager Bay.

Once the sea had eroded ice crossing the west end of Ford Lake, the final phases of Glacial Lake Brown dropped to the marine limit at about 95 m, ending the lake phase. Late ice patches remained for a short time in the east end of Brown Lake and the western extremities of the finger lakes, so that the highest marine limit recorded in those areas is at about 80 m. A tiny late remnant of the southern finger lake drained to that level.

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