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Features

Active Earth

The Rise and Fall of a Small Lake

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Introduction

In the early fall of 1974, in the Senneterre area of southwestern Quebec, two fishermen decided to try their luck in a small lake which was at a higher elevation and separated from a larger one by a narrow ridge of sand and gravel. When they arrived at the site it was decided for some obscure reason to go back to camp and return later to the small lake. Before leaving, one of the fishermen made a small drainageway with his boots across the crest of the gravel ridge, to allow water to trickle from the nearly overflowing small lake into the larger one below. When they came back a few hours later the small lake had disappeared, washing away thousands of cubic metres of sand and gravel. This catastrophic event was followed by another surprise—the discovery of *in situ* flat-topped tree stumps on the floor of the drained lake. Mystery was in the air!

A fishing story? Yes, inasmuch as it was reported by fishermen. But cases of stream piracy, naturally dammed lakes and ponds and other examples of "deranged" drainage are numerous in the relatively young deglaciated terrain of northern Canada. These commonly occur in granular ice-contact deposits. While such examples are more evident in terrain north of the treeline, they are also numerous in the boreal forest of the Canadian Shield.

E.A. Godby, back from a trip in the Senneterre area in late summer 1975, reported the story of the drained lake to W. Blake, Jr. of the Geological Survey of Canada and submitted wood collected from the drained lake floor for radiometric dating. Details of the lake drainage were related to Godby by Rita Bérubé from Senneterre. Intriguing to Godby and his fellow travellers, among whom was a geologist, were the flat-topped *in situ* stumps, as if the trees had been cut by a saw or sheared off by some natural catastrophic event. Blake hypothesized that the flat tops of the stumps could date back to the time of deglaciation of the area and may mark a local readvance or oscillation of the ice front that would have levelled trees growing near the glacier. The wood could then have been preserved under water since that time.

On the basis of this possible interest for deglaciation chronology, and to document an unusual and intriguing landscape modification, I visited the site on July 22 and 23, 1978 at Blake's request.

Site Description

The drained lake is located about 65 km east of Senneterre (Fig. 1) and 7 km south of the Canadian National Railway Forsythe siding, in an area of abundant fluvioglacial deposits. Prior to drainage the small lake was separated from the larger lac l'Espérance by an esker ridge and breaching occurred at the narrowest point (Fig. 2). Lac l'Espérance stands at an elevation of 400.9 m and the well-preserved shoreline left by the drained lake is at 407.3 m (absolute elevations were obtained with altimeters tied to an EMR bench mark (BM-66-1-121) in Forsythe). The level of the residual pond in the deepest part of the basin (Fig. 3) is about 0.7 m above lac l'Espérance. The pond is separated from lac l'Espérance by a land bridge which resisted the catastrophic drainage. Figure 4 shows a ground view of the land bridge and the shoreline left by the drained lake. The significance of this land bridge will be discussed later.

Materials exposed in the bottom and flanks of the drained lake consist of bedrock, sand and gravel, gyttja, and scattered coarse organic debris. The basin has the shape of a slightly sinuous, flat-bottom trough inclined towards the esker. A small stream, visible in Figure 3, drains the marshy grounds to the west.

Breaching of the Esker

According to Mr. Côté, a local fishing and hunting outfitter, breaching of the esker and drainage of the lake required less than 3 hours. For some years Côté had noticed that following heavy rains and at periods of high water level such as spring melt-out the water level of the small lake was nearly up to the crest of the esker. The digging of the small drainageway on the esker crest so that water could escape into lac l'Espérance probably just speeded up a process that was about to occur naturally.

A minimum volume of 12,800 m^3 of sand and gravel—a segment of esker 8 m high, 50 m wide and 64 m long—was washed away (Fig. 5). The volume of granular material removed is probably larger as the base level for the above estimate is the level of lac l'Espérance. Water now occupies the base of the breach in the esker, and soundings within it to a depth of 2.8 m failed to reach bottom. Since lake level was at 407.3 m prior to drainage, the point on

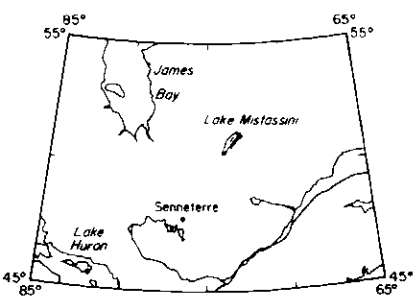

Figure 1 *Location of the drained lake near Senneterre, Quebec.*

the esker where downcutting was initiated was at or slightly above this elevation. The maximum elevations of the two flanks of the breach are comparable—410.6 m—and indicate that downcutting was initiated in a saddle-like depression on the esker crest. This depression is faintly visible in the stereogram of Figure 2.

In Situ Tree Stumps on the Lake Floor

The most curious feature of the lake floor is the isolated, dark brown "old-looking" *in situ* tree stumps which were covered by as much as 5 m of water prior to lake drainage. Many stumps have smooth, nearly flat tops, whereas a few have pointed tops (Fig. 6). Early observers reported only the more striking flat-topped stumps, apparently neglecting to observe or to mention the much rarer pointed ones. Apart from the stumps, what must have been waterlogged tree logs and sticks were found scattered on the lake bottom. Close inspection of some of these presumably "old" logs showed that those lying in the deepest parts of the basin also had flat upper surfaces similar to those of the erect stumps (Fig. 7).

The presence of *in situ* stumps subsequently covered by a few metres of water requires an explanation. There is no evidence of wrenching or uprooting on any of the stumps examined and, consequently, mechanical disturbance by a natural powerful agent such as flowing ice must be ruled out. All tree stumps appear to have been cut at a comparable height (approximately 40 cm) above ground level. The pointed ones are remarkably similar to stumps left by beavers, although no beaver teeth marks are obvious on their surfaces. Similarly, several sticks and logs on the lake floor show the typical pointed ends of beaver cuts. Although the flat-topped stumps cannot be directly attributed to beavers they could represent pointed stumps that have been levelled by water action or some other erosive mechanism. There is a distinct association between deep water and flat-topped stumps, and shallower water and pointed stumps. Apart from this relationship no satisfactory explanation can be found for the flat-topped tree stumps.

The presence of *in situ* wood in the basin allows accurate dating of the early stages of the lake, and beaver intervention helps us to understand the mechanisms responsible for its build-up.

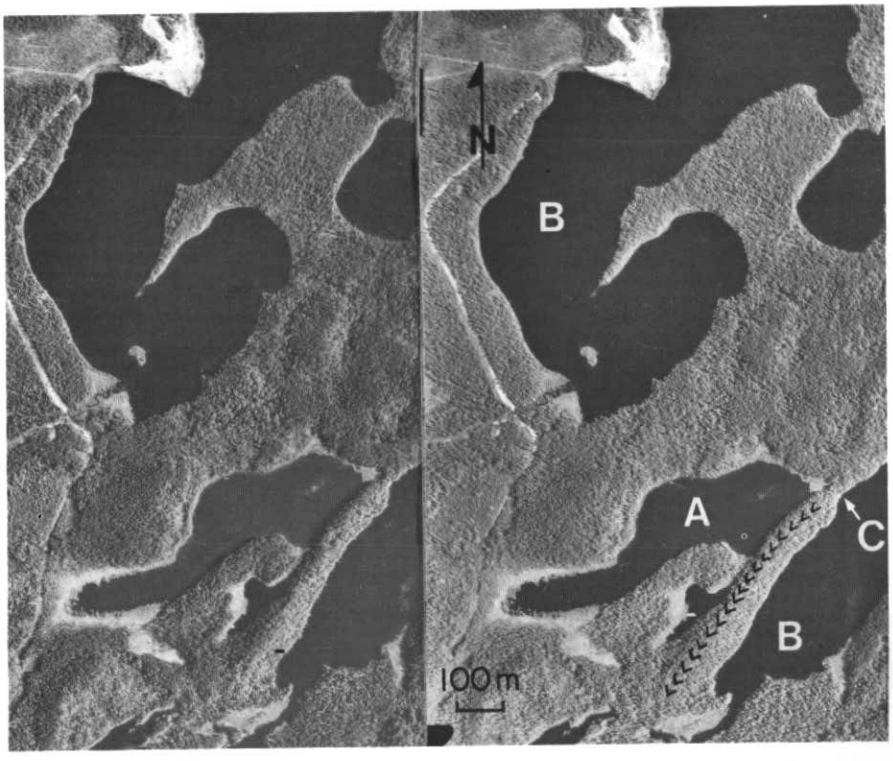

Figure 2 *Stereopair showing small lake and surrounding area before drainage. Aerial photographs Q72822-122 and 123 were taken in 1973, from Ministère de l'Energie et des ressources, service de la cartographie, Quebec. Scale is 1:15 000. A: small lake; B: lac l'Espérance; C: point where breaching of esker occurred. Small lake is at 48°11'Lat.N and 76° 26' Long.W.*

Figure 3 *Aerial photograph of small lake basin after drainage. From aerial photograph A24060-79, Energy Mines and Resources, Canada, taken in 1975 at a scale of 1:60 000 and enlarged to 1:15 000 (Geological Survey of Canada photograph 203971-A). A: breach in esker; B: land bridge; C: residual pond; D: stream on lake bottom.*

Age and Formation of the Lake

A flat-topped stump of *Larix laricina* found at an elevation of 402 m, a few metres west of the west end of the residual pond (Fig. 2), gave an age of 3690 ± 70 BP (GSC-3479) and a pointed stump of *Picea*, found at 404 m in the western shallower portion of the basin, gave an age 2910 ± 80 BP (GSC-3501). Only the outside wood was used for dating. R.J. Mott (Wood Identification Report 78-55, Geological Survey of Canada) identified the trees.

Beavers probably participated in the creation of the lake, which apparently started with a pond much similar to the residual one now present in the lake basin. The land bridge mentioned before (Figs. 3 and 4) covers what is thought to be the initial beaver dam that held back the water of a small ancient stream flowing from the west, similar to the one flowing today along the longitudinal axis of the dry basin. Probing on the bridge to depths of 2 and 3 m revealed a layered structure with a lowermost portion of compact wood pieces (the ancient beaver dam?), an intermediate layer of organic debris and gyttja containing less wood and an uppermost layer of sand and gravel, probably deposited during lake drainage. A time span of between 930 and 630 years was required for a rise of 2 m in the basin between the two dated stumps. A gradual rise of this magnitude is incompatible with the well preserved condition of the dated stumps. Rises in water level were probably abrupt, occurring at irregular intervals. Only those stumps rapidly covered with water were preserved; the dated stumps thus probably mark periods of rapid rise in water level. Assuming that beaver intervention was a major factor in the creation of the lake the following sequence of events is proposed:

(1) The stream from the west initially seeps through the granular base of the esker into lac l'Espérance.
(2) Beaver activity immediately west of the esker starts some time before 3690 ± 70 years ago. The overflow caused by the beaver dam continues to seep through the previous esker.
(3) Ponding increases the rate of formation and sedimentation of fine organic matter, some of which is deposited against the flank of the esker. This process gradually seals the lake from the pervious esker; this organic seal is visible in Figure 4.
(4) By 2910 ± 80 years ago the total rise in water directly above the base of the now buried beaver dam is about 5.5 m.
(5) By 1974 (or before) the water has reached the upper level of the esker and is 8.8 m above the base of the buried dam. Organic matter has now effectively sealed the esker and the natural process of overflow and downcutting of the esker has become unavoidable.

Significance of the Forsythe Drained Lake

The oldest date, 3690 ± 70 years, gives a minimum age for beaver occupation of the area and a minimum age for the start of lake formation. Since colonization in this area by vegetation following deglaciation occurred about 9,000 years ago (based on a date of 9120 ± 290 years (GSC-3386) obtained on basal gyttja from a pond 55 km southwest of the drained lake), it is unlikely that the stream flowing from the west into the lake basin and seeping through the esker did so for about 5,300 years without sealing the esker with organics or simply undercutting it. It seems more probable that the stream marks a change in the hydrological conditions of the site (in response to increased precipitation?) and was probably absent or very small prior to 3690 ± 70 years.

If the base of the wood accumulation below the land bridge (Fig. 8) is a beaver dam built at stream level prior to 3690 70 years ago, then the base level of the stream (lac l'Espérance) was at about 2 m lower than it is today. Lower lacustrine levels associated

Figure 4 *Ground view of the drained lake seen from the esker crest. Arrows show former shoreline. The two persons are standing on the land bridge. Note accumulation of organics on the esker flank. Geological Survey of Canada photograph 203407-Q.*

Figure 5 *View of breach in esker from a high point within the drained lake basin. Geological Survey of Canada photograph 203407-0.*

with warmer and drier climates during the Hypsithermal period are better documented in the Prairies than in Eastern Canada. Teller and Last (1982, 1981) have demonstrated this condition for Lake Manitoba. But in Eastern Canada field observations at some locations suggest that the regional water table and the level of water bodies also were lower than today. Pierre Richard (1977) reports concentrations of tree logs approximately 5,600 years old at about 3 m below the surface in the mid portion of two peat bogs in south-central Quebec. Henri Dinel (1983 personal communication) reports that the water table in the Keswick marsh adjacent and connected to Lake Simcoe, Ontario was at least 2.40 m below its present level about 4,000 years ago, with the Lake Simcoe level lower by about 2 m than at present. Similar drier conditions may have been present at the Forsythe drained lake prior to its formation 4,000 years ago.

The Forsythe drained lake presents an interesting combination of hydrological, biological and geomorphological conditions which first led to the creation of a lake and then caused its destruction. It illustrates in a spectacular way the interactions of factors we too often consider and study independently.

Acknowledgments

W. Blake Jr. supplied preliminary information on the site, contributed the radiocarbon ages through the Laboratory of Geochronology of the Geological Survey of Canada and commented on the manuscript. E.A. Godby and Mr. Côté provided information on the lake drainage in 1974. P. Richard, J. Bednarski and H. Dumych commented on the manuscript. J.M. Moisan and M. Veillette assisted in the field.

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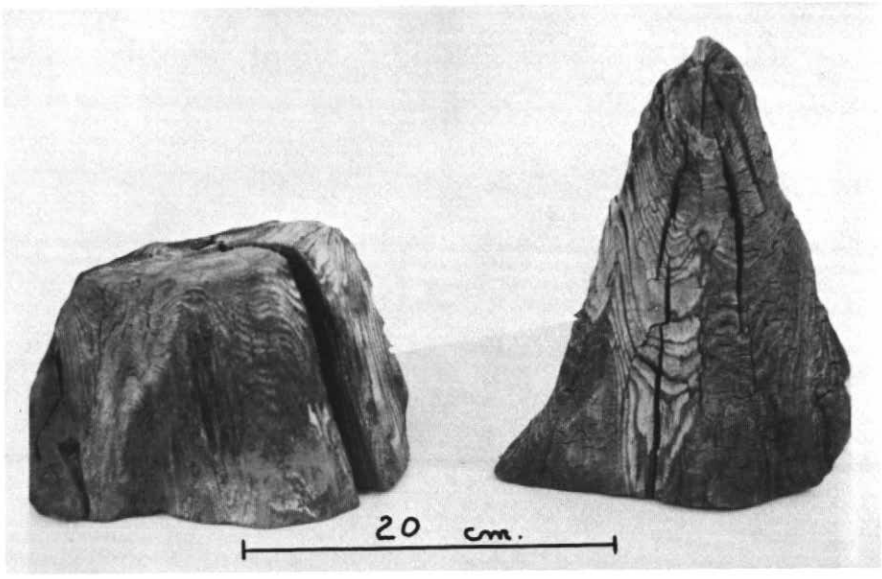

Figure 6 *The two types of tree stumps found on the lake floor. Left: flat-topped stump of* Larix laricina; *right: pointed stump of* Picea. *Geological Survey of Canada photograph 203407-R.*

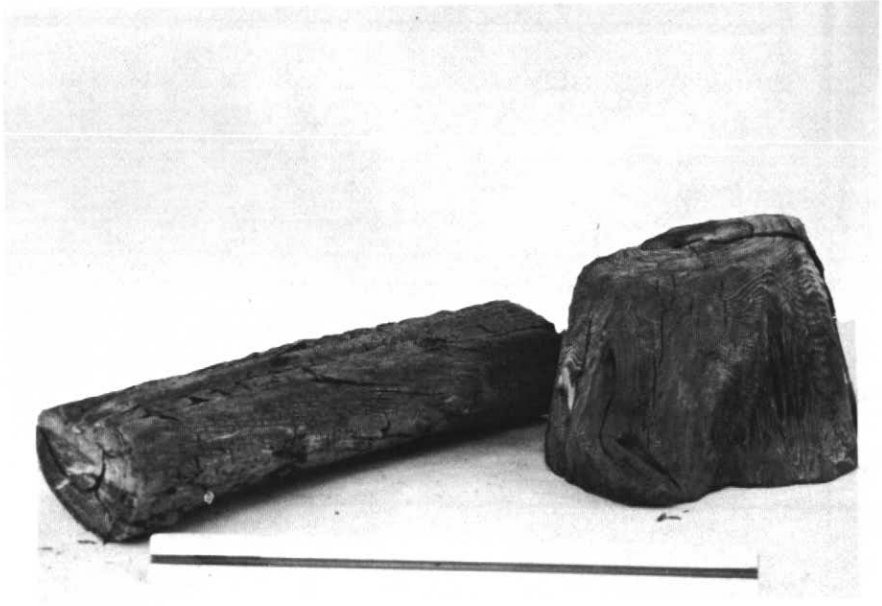

Figure 7 *Section of log with flat upper surface, found lying on drained lake floor (left) and flat-topped stump (shown on Fig. 6). Geological Survey of Canada photograph 203990.*

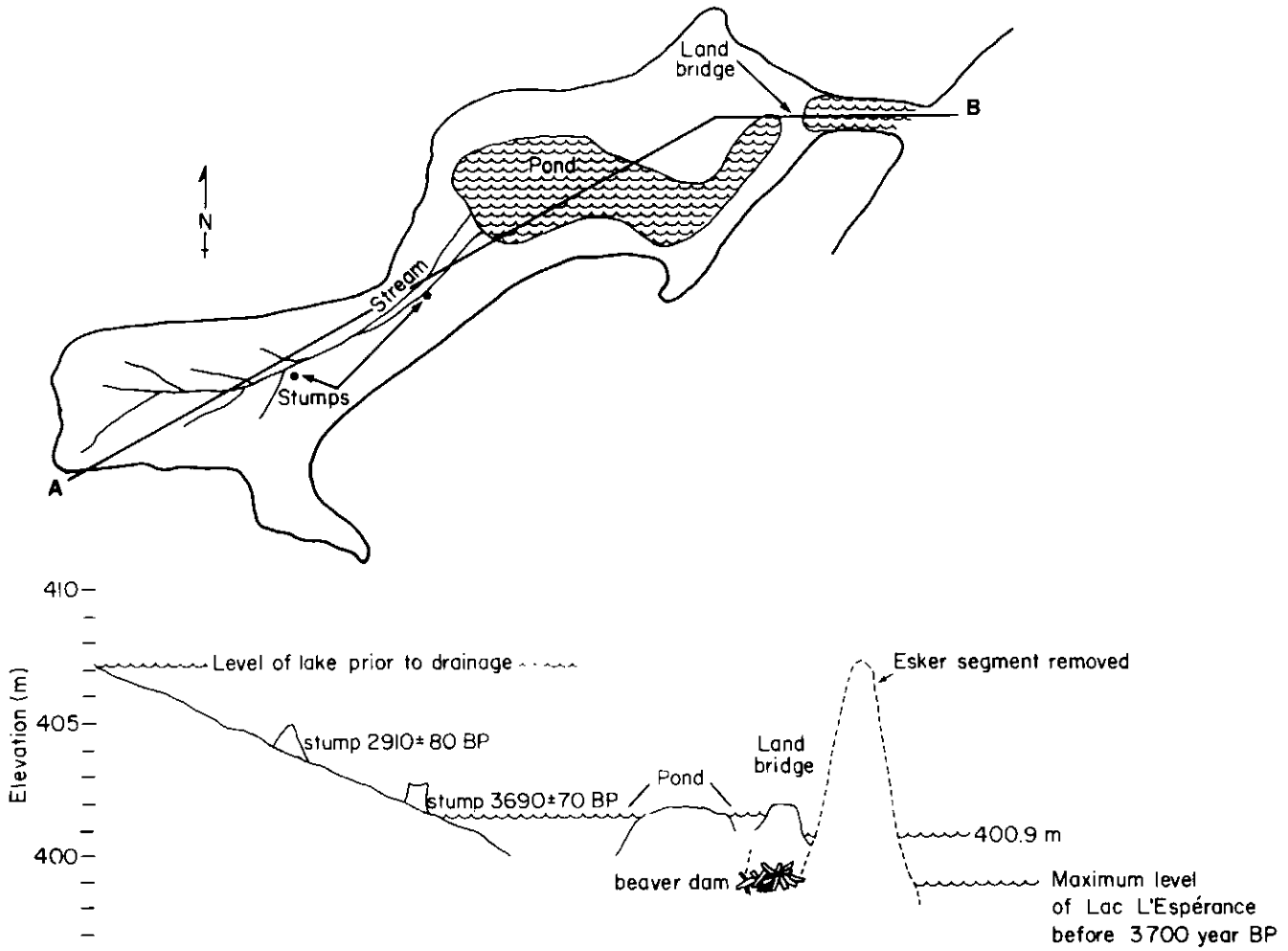

Figure 8 *Longitudinal profile of the small lake basin. The base of the beaver dam is 2 m below the present level of lac l'Espérance.*