EASTERN OUTLETS OF LAKE AGASSIZ

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Introduction

Glacial Lake Agassiz occupied large areas in Manitoba and Ontario, extending southward into North Dakota and Minnesota and westward into Saskatchewan. In the initial high water stages it drained south into the Mississippi River system through Lake Traverse in Minnesota. As ice recession uncovered lower outlets, the lake drained east into the Lake Superior drainage basin (Upham 1896; Leverett 1932; Johnston 1946; Elson 1957). Evidence shows that two, or possibly three high level lakes existed (Elson 1965), separated by significantly lower water stages. It is assumed that the intervening low stages and the initial final low water stages drained to the east (Elson 1957; Laird 1964). Eslon (1957) located the possible eastern outlets, the Brule, Kaministikwia, Kaiashk, Pillar and Pikitigushi channels from erosional features recognized on aerial photographs, but subsequent field observations failed to confirm this function of the Brule and Kaministikwia channels (Zoltai 1963). The other eastern outlets were discussed by Zoltai (1965), but the sill elevations were not determined. This paper describes these eastern outlets and relates their opening and closing to fluctuating ice movements.

Elevation of outlet sills and wave-cut terraces occurring at high altitudes were determined by A.H. Aldred. This was done by interpolation of the Canada Department of Forestry and Rural Development, Forest Management Research Section, Ottawa, Ontario using National Topographic Series maps showing 100-foot contours. The elevations were checked on aerial photographs (scale approx. 1:70,000), using a parallax bar with a graphical correction method, as outlined by Moffitt (1959). The elevations are believed to be accurate within 25 feet. This method was adopted because of the inaccessibility of this heavily wooded area.

The Eastern Outlets

The outlet channels were recognized from erosional and depositional features. Most channels originated in moderately rolling areas of Precambrian bedrock hills having a thin till mantle. The upper reaches of the channels are located in valleys between these bedrock hills or in fault valleys which are now occupied by underfit streams or lakes. The erosive action of water removed the loose material from valley floors, leaving only large boulders. The downstream parts of the channels were cut through lacustrine or outwash sand plains, leaving well defined troughs which are often floored by gravel. Most channels end in deltaic deposits. Figure 17 shows the location of these outlet channels, and the elevation of sills are given in Table 8.

The Kaiashk outlet

This outlet originated in three distinct branches, here named the Roaring River, Pantagruel and Rabelais Creek channels (Nos. 1a, 1b and 1c in Fig. 17 and Table 8). A fourth branch, the Awkward Lake channel (1d), initially entered into the main Kaiashk channel, but later it assumed an easterly direction, possibly after eroding a drift barrier. The main Kaiashk channel ends in a lacustrine and outwash sand plain of later origin which obliterated any deltaic deposits that may have existed.

The sill elevations show that initially all four branches functioned simultaneously, eroding the thin drift cover in their beds to bedrock in all but the Pantagruel channel. Later the sill of this channel was also eroded to bedrock, which, being at a lower elevation, reduced the volume of water in the other channels. The Pantagruel channel is the largest and broadest of the tributaries comprising the Kaiashk outlet.

Pillar and Armstrong outlets

The main channel of the Pillar outlet was composed of four narrow branches, the Chief Lake, Track Lake, Badwater Lake and Little Caribou Lake Channels (Nos. 2a, 2b, 2c, and 2d). The tributaries followed valleys and faults among bedrock, but the main Pillar channel was eroded in outwash sand and gravel of the nearby Nipigon moraine, ending in a large delta.

The main Pillar channel follows the Nipigon moraine, nowhere crossing it in spite of the presence of low passes. The little Caribou branch, however, crossed the moraine before joining the main channel, and later it established a direct easterly route, independent of the Pillar channel, after eroding the Armstrong outlet (No. 3). The courses taken by the channels suggests that the Chief, Track and Badwater lakes channels functioned first, forming the main Pillar channel after becoming confluent. Ice at the Nipigon moraine caused the Pillar channel to flow to the south, but later a partial withdrawal of ice opened the Little Caribou channel, joining the well entrenched Pillar channel. Further ice withdrawal then permitted the Armstrong channel to drain directly to the east.

Big Lake outlet

Farther north the Big Lake outlet (No. 4) was eroded across the Nipigon moraine at lower elevations than the Pillar and Armstrong outlets. The channel is often scoured to bedrock and

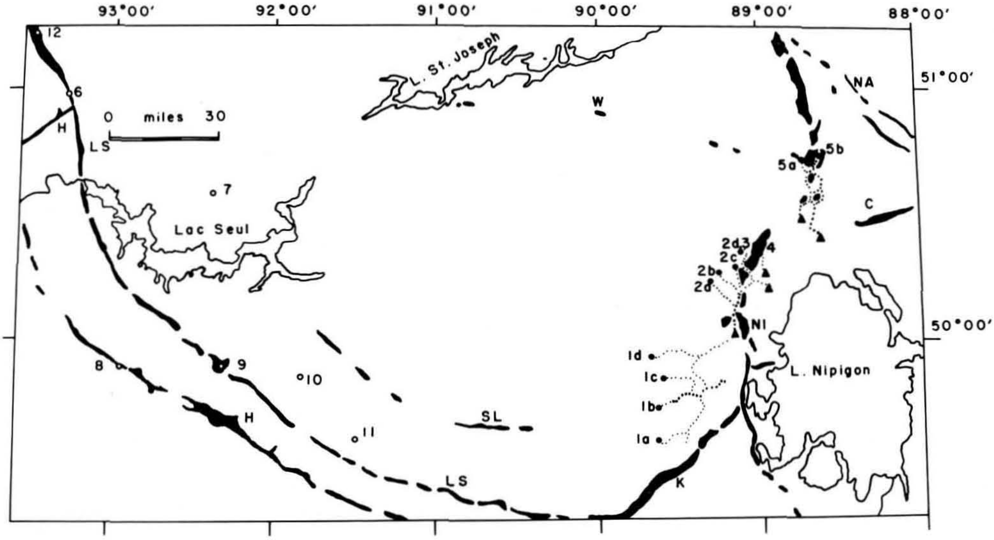

Figure 17. Map of area containing the eastern outlets of Lake Agassiz, showing moraines and location of wave-cut bluffs. Outlets are dotted and numbered 1 to 5, as in text. Land features with bluffs are numbered 6 to 12. Deltas are shown by triangles. Moraines are identified by letters: H, Hartmann; LS, Lac Seul; SL, Sioux Lookout; NI, Nipigon; W, Whitewater; NA, Nakina moraines; C, Crescent moraine; and K, Kaiashk interlobate moraine.

TABLE 8

PRESENT ELEVATIONS OF OUTLET SILLS

Outlet	Channel	Elevation (feet)	Location Longitude	Location Latitude
1. Kaiashk	1a. Roaring R.	1375	89°38'30"	49°37'30"
	1b. Pantagruel Cr.	1375	89°37'00"	49°44'15"
	1c. Rabelais Cr.	1420	89°34'15"	49°49'45"
	1d. Awkward L.	1425	89°39'30"	49°57'30"
2. Pillar	2a. Chief L.	1265	89°20'00"	50°16'00"
	2b. Track L.	1245	89°14'45"	50°16'30"
	2c. Badwater L.	1252	89° 8'30"	50°18'45"
	2d. Little Caribou L.	1256	89° 7'30"	50°23'30"
3. Armstrong	3. Little Caribou L.	1256	89° 7'30"	50°23'30"
4. Big Lake	4. Big Lake	1175	88°58'30"	50°24'00"
5. Pikitigushi	5a. Raymond R.	1125	88°44'00"	50°44'30"
	5b. Clearbed L.	1125	88°39'00"	50°46'30"

contains numerous large boulders, and ends in a small delta. Although this channel is well defined, it appears to be too small to accommodate the outflow of Lake Agassiz.

Pikitigushi outlet

This outlet system originated in two channels, the Raymond River and Clearbed Lake channels (Nos. 5a, 5b). These channels followed an intricately forked course through the Nipigon moraine and among tablelands, ending in a large delta.

Shore Features

Shore features are of limited occurrence in the area (Fig. 17) because materials suitable for the formation of these features rarely occurred at elevations exposed to wave action. The terraces at locations 6, 8, 9 and 12 occur on high portions of moraines and the others on high, isolated kames. Examination of aerial photographs shows that the highest portions of these moraines and kames were inundated only at location 11. Deep kettles occur on the unmodified parts of these moraines and kames. All these high drift hills show four to six lower strandlines, but their elevation was not determined. Prest (1963) noted that the highest parts of the Lac Seul moraine in the northwestern part of the map (Fig. 17) escaped modification by the lake. The most northerly of these ridges is at location 12.

The present elevations of the wave-cut terraces (Table 9) show that they were cut by a high level stage of Lake Agassiz. The scarp at location 11 is at a lower elevation than the other terraces, and records a lower stage of the Lake, having been completely submerged in the high water stage.

Correlation of Outlets and Shore Features

The water plane indicated by shore features at high altitude was reconstructed in the assumed direction of uplift, N30°E, and the outlet levels were plotted normal to this line (Fig. 18). This direction of uplift was based on Johnston's (1946) work who found it to be between N27°30'E in the main Lake Agassiz basin, and on Farrand's (1960) work who established it to be N30°E in the Lake Superior basin.

Figure 18 shows that the terraces at high altitudes correlate well with a beach at Emo, Ontario, about 85 miles southwest of the map area, which is believed to be an Upper Campbell beach (Johnston 1946). The completely submerged kame at location 11 falls below this water plane, but is well above the Kaiashk outlet. The

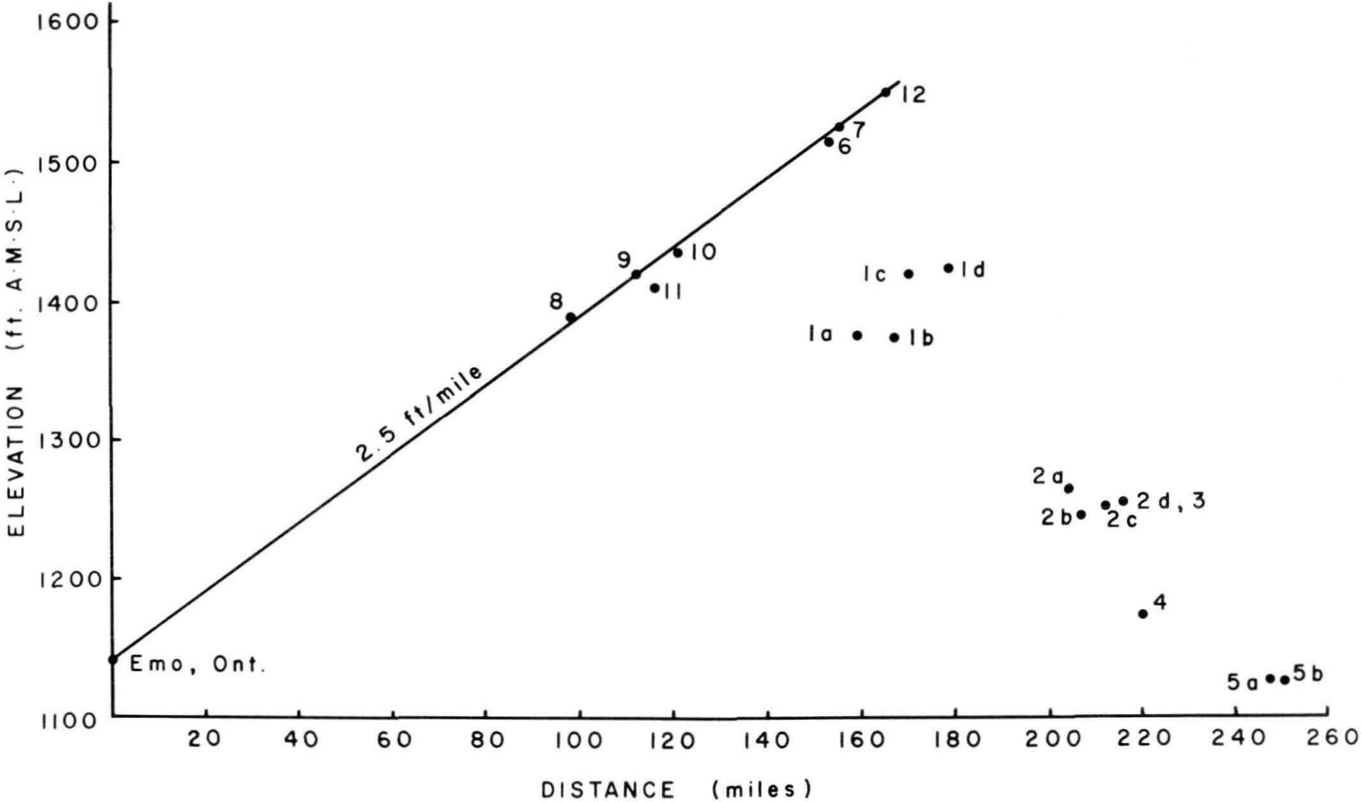

Figure 18. Water plane reconstructed in the assumed direction of uplift, N30°E, based on present elevations of shore features and outlet elevations. Bluffs (Nos. 6 to 12) and outlets (Nos. 1 to 5) are shown by dots.

TABLE 9

PRESENT ELEVATIONS OF HIGH TERRACES

Number Fig. 17	Elevation (feet)	Location	
		Longitude	Latitude
6	1515	93°11'00"	50°57'00"
7	1525	92°25'15"	50°39'45"
8	1390	92°54'00"	49°53'30"
9	1420	92°18'30"	49°55'15"
10	1435	91°48'30"	49°52'15"
11	1410	91°27'30"	49°39'15"
12[a]	1550	93°00'00"	51°11'45"

[a]Data from Prest (1963).

indicated rate of uplift is about 2.5 feet per mile, a rate higher than that obtained by Johnston (1946) in the main Lake Agassiz basin. Johnston's data show that the rate of uplift increases to the northwest, thus the greater rate of uplift indicated by the water plane is acceptable and appears to be of the right order of magnitude.

The Kaiashk outlet elevations fall about 160 feet below the high shore features, as shown in Fig. 18. The sill elevations of the Pillar outlet are about 220 feet lower than the Kaiashk outlet, indicating a considerably lower lake level. Because of the great distance between these outlets and lower beaches of Lake Agassiz, the correlation of these outlets with lake stages is not possible. The highest beaches occurring on the Windigo moraine at 1350 feet elevation, some 110 miles north of Lake St. Joseph (Prest 1963) may be related to the Pillar outlet system.

It is unlikely that the Big Lake channel represents an outlet of Lake Agassiz. A lowering of the lake level of 85 feet from the Pillar to the Big Lake outlet would have elevated the land above the lake level, severing any connection with the main part of Lake Agassiz. This channel probably served as an outlet of a small ice-marginal lake.

The outlet elevations of the Pikitigushi channels at 1125 feet are on the estimated level of Glacial Lake Nakina (Zoltai 1965), a long, narrow ice-marginal lake. The outlet elevation of the Jellicoe outlet of Lake Nakina farther to the southeast is 1130 feet (Zoltai in press), showing that the Pikitigushi channel was another, perhaps later outlet of Lake Nakina. However, Lake Agassiz may have drained into Lake Nakina farther north (Prest, personal communication).

Correlation of Outlets With Ice Movements

Outlets of the first high water stage of Lake Agassiz were not found in the east. The lowest stable water level of this lake was at the Norcross beach (Elson 1965), and the lake drained to the south through the Lake Traverse outlet. The lake was confined in the north by a receding ice front and in the east by Precambrian highlands. Field observations (Zoltai 1961) showed that the ice front became stationary at the Hartmann moraine in the west. A more extensive retreat may have occurred in the east, possibly through more rapid wastage in glacial lakes in the Superior and Nipigon basins. This could have uncovered lower outlets in the east, possibly in the Kaiashk area. Any such outlets, however, were obliterated by the subsequent Valders readvance which built the Kaiashk interlobate moraine and the Dog Lake moraine (Zoltai 1965).

The second high stage of Lake Agassiz was created by the advancing Valders ice, blocking the eastern outlets (Elson 1957). The lake level rose to the Norcross beach, but was later lowered to the Upper Campbell beach (Elson, personal communication). At this stage the lake was confined in the northeast by ice at the Hartmann moraine (Zoltai 1965). The ice then receded and later readvanced to the Lac Seul moraine. The extent of this retreat is not known, but a retreat and readvance of at least 20 miles is indicated by overridden varved clays in the Lac Seul area. A retreat of similar extent in the east would have opened outlets in the Kaiashk area. If an outlet was indeed opened, then the level of Lake Agassiz was first lowered and later raised to the Upper Campbell level as this outlet was closed by the readvance to the Lac Seul moraine. This lake level was maintained until the resumption of ice retreat following a recessional pause at the Sioux Lookout moraine (Fig. 19).

Ice retreating from the Sioux Lookout moraine again became stationary a short distance farther north, after uncovering the Kaiashk outlet of Lake Agassiz (Fig. 20). Further ice retreat of unknown magnitude followed. If the ice retreated far enough, the outlets in the Pillar area would have been opened. Any further lowering of the lake levels through lower outlets would have exposed so much land above lake levels, that an eastern outlet in the map area would be improbable.

Ice then advanced from the east to the Nipigon moraine, abutting on the stagnant ice mass of the northern ice lobe which was stationary at the Whitewater moraine. This readvance deflected the main channel of the Pillar outlet along the ice front at the Nipigon moraine (Fig. 21).

Further ice retreat followed, accompanied by uplift of the land as the weight of the ice was removed, and large areas, including the Pillar outlet emerged as dry land. A further renewal of glacial activity resulted in a readvance to the Nakina moraine in the south (Zoltai 1965) and to the Agutua moraine in the north (Prest 1963). Lake Agassiz possibly inundated a long, narrow bay in front of the Agutua moraine (Fig. 22) to an elevation of 1200 feet (Prest, personal communication). Lake Nakina, a long, narrow lake was formed in front of the Nakina moraine. This lake was initially confluent with a high water lake stage in the Superior basin, but crustal uplift severed connection with the Superior basin and the independent Lake Nakina was established (Zoltai in press), consisting of two basins separated by shallows. One basin drained from the east into the Lake Nipigon basin through the Jellicoe outlet (Zoltai in press), and the other through the Pikitigushi outlet. Lake Agassiz may have drained into Lake Nakina along the ice front, possibly through several channels as the melting ice uncovered lower areas. Upon the resumption of the final ice retreat lower outlets may have become available in the north, but continuing uplift makes it improbably that these drained to the east.

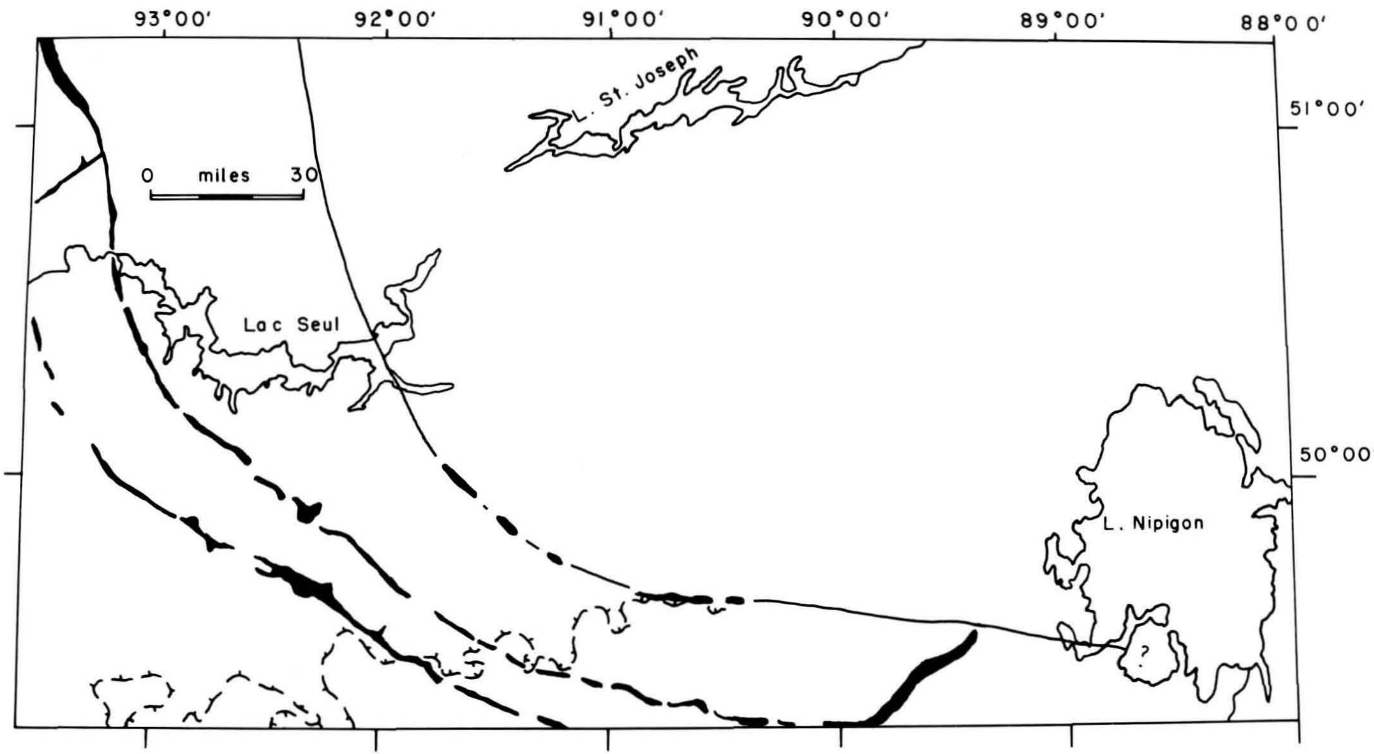

Figure 19. Eastern extent of Lake Agassiz during the Upper Campbell stage, with ice front at the Sioux Lookout moraine.

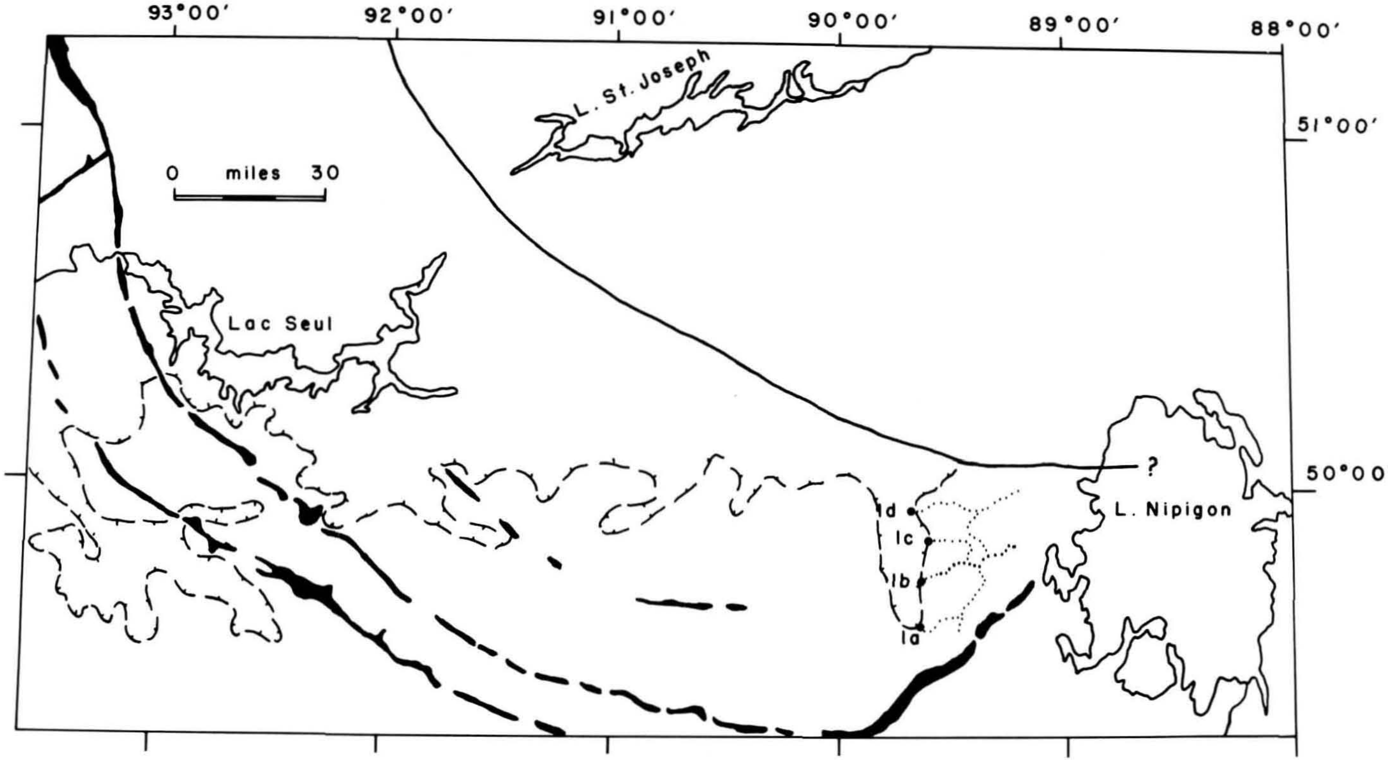

Figure 20. Eastern extent of Lake Agassiz during the Kaiashk outlet stage.

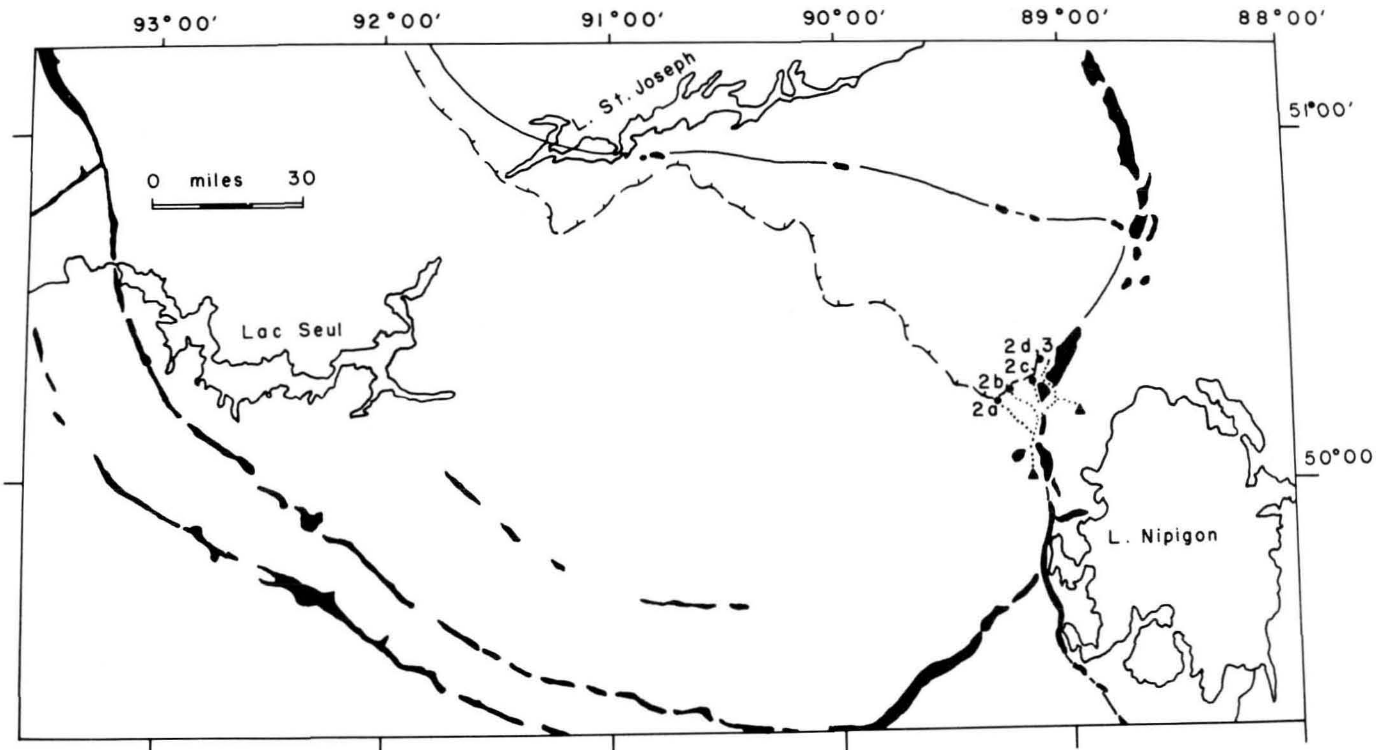

Figure 21. Eastern extent of Lake Agassiz during the Pillar outlet stage.

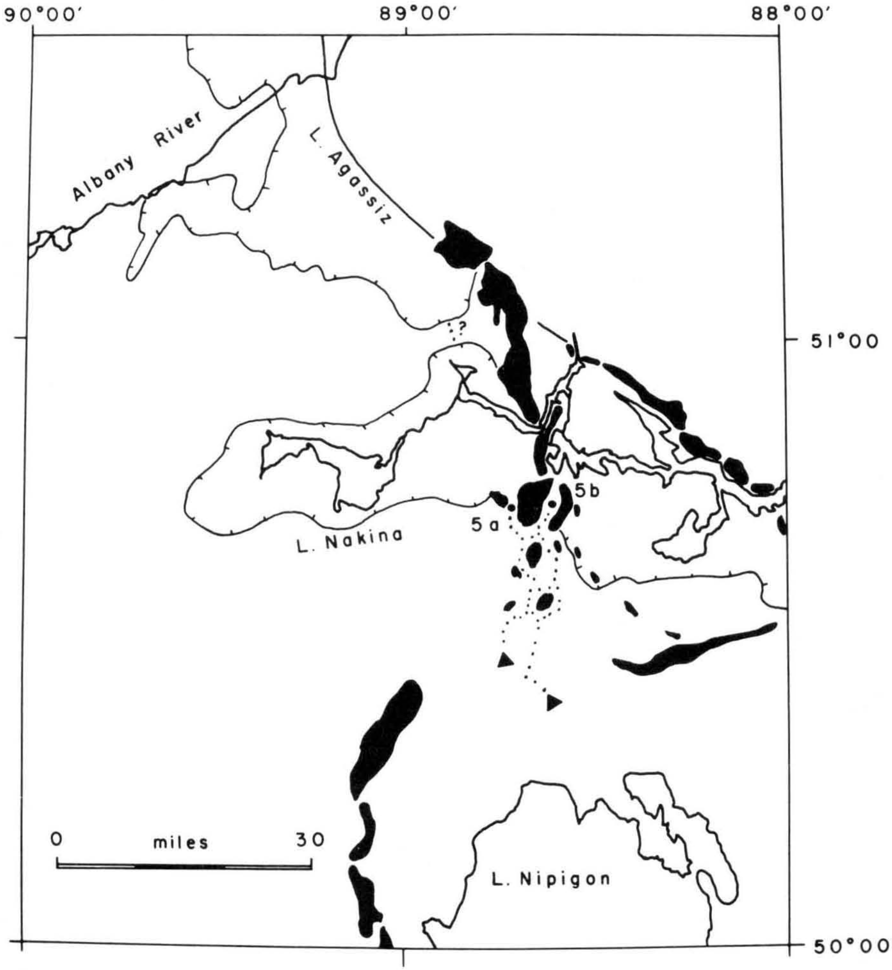

Figure 22. Eastern extent of Lake Agassiz with Lake Nakina during the Pikitigushi outlet stage.

Summary Conclusions

1. No outlets were found in the east which drained Lake Agassiz when the lake level stood at or above the Campbell beaches.

2. On two occasions ice retreats and readvances may have opened and closed eastern outlets prior to the final lowering of the lake, but the readvances which closed these outlets also obliterated any evidence of them. Consequently, there is no direct evidence of these early eastern outlets, and indications of two early low water stages of Lake Agassiz should be obtained in the undisturbed part of the main Agassiz basin.

3. The early eastern outlets were closed by the Valders readvance and by the ice readvance to the Lac Seul moraine. The indication that lake levels reoccupied the beaches the lake built before the opening of the lower outlets implies that little crustal uplift took place during the low water intervals, and that these intervals were of short duration.

4. The early eastern outlets may have lowered the lake level by as much as 380 and 160 feet, respectively, but complete drainage of the lake could not have taken place at this time.

5. Direct evidence indicates three eastern outlets of Lake Agassiz at a later stage, namely the Kaiashk and Pillar outlets, and a possible indirect drainage through the Pikitigushi outlet. Lake levels controlled by the Pillar outlet may have preceded by a lower water stage, followed by a rise to this outlet as ice readvanced to the Nipigon moraine.

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