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GLACIAL TRAVERSE ACROSS THE SOUTHERN SIDE OF AN ICE CAP

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INTRODUCTION

During the last decade considerable debate has developed between workers in southern New England and workers in the Maritime Provinces over glaciation style. Field data from southern New England shows a progressive retreat of the ice front from it's maximum limit on Long Island northward through Connecticut, Rhode Island, and Massachusetts into New Hampshire and Vermont. Furthermore, coastal Maine shows recession of active ice to at least the marine limit (Smith, 1982).

In contrast, the Gaspe, New Brunswick, Cape Breton Island and Nova Scotia all show evidence of interconnected and interacting ice masses. Grant (1977) suggested the maximum extent of these during the late Wisconsin may be the near present coastline. Thus ice recession proceeded from several directions at once.

Debate over these two glaciation models has been active for several years and is not likely to be settled soon. However, these two models imply vastly different ice extents and ice limits, so they are important and require rigorous testing. Similar arguments exist in Newfoundland (see Brookes, 1982 for a interesting review).

One way to view the conflict is that it stemmed from chance placement of political boundaries which later dictated different research approaches: Americans developed one model whereas Canadians support a different model. Thus it may be largely the result of misunderstanding, lack of communication, or lack of data in the interlying areas. The primary purpose of my mapping since 1979 is to reduce the last problem. By selecting an unmapped area central to those suggested contrasting glacial styles, one might find evidence supporting one or the other, or one might find a large gray zone between black and white.

A second development helping our present understanding of the region is the compilation of 1:500,000 scale maps of New Brunswick (Rampton, in press) and Maine (Thompson and others, in press). These maps allow the relationships of moraine distribution, esker distribution and changes in ice-flow indicators to be studied at previously unavailable scales.

As these data are analyzed and studied in a regional context, a better understanding of the regional events should emerge. This trip traverses the area of current research, and should be viewed as an open forum for discussion to look at some old problems in a new light.

ICE-FLOW PATTERNS OF NORTHERN MAINE AND ADJACENT AREAS

The study of ice-flow patterns requires that sufficient data over a wide area be assembled before their meaning can be incorporated into glaciation models. Thus it is necessary to draw on the work of others in addition to presentation of original work. In the following, I will present the ice flow patters deduced from my work in northwestern Maine, add pertinent works from southern Maine and New Brunswick, and suggest a glaciation style somewhat in variance to more classical views of the area. Discussion of this suggestion is requested.

From maps published by LaSalle and others (1977), one easily sees northward ice-flow indicators. However, upon closer examination, one also finds localities where the northward flow lies upon evidence of eastward flow. The eastward flow does not seem to have been influenced by the St. Lawrence Valley. Indeed, Occhietti (Fig. 12, 1982) suggested the origin of this flow as being from the Laurentide Park Highlands during growth of the Nouveau-Quebec Ice Cap.

Lowell (1980a, in press) and Kite and others (1982) reported extensive ice-flow evidence from northwesternmost Maine. The first glacier flow is also directed to the east or east-southeast. Grant (personal communication) suggested a pre-late Wisconsin age for this flow. If so, then the superposed extensive northward flow in Maine, Quebec and New Brunswick must represent the flow origination from an independent ice cap over Maine and the Maritime Provinces that persisted throughout the late Wisconsin; this precludes the influence of Laurentide ice in the region. However, based on striation distribution, lack of weathering between the striation sets, and till studies I suggest that it is of regional importance and occurred during the early phases of the late Wisconsin. Becker (1982) supports this interpretation based on studies of stratigraphic sections along the St. John River.

Moving southward from northernmost Maine the evidence for east/ east-southeast ice-flow becomes stronger. In the region of Ross Lake the evidence of northward flowing ice disappears and only the east/east-southeast indicators remain. Hyland (1981) reported, from north central Maine, that the earliest ice-flow was also to the east-southeast. However, superposed upon these indicators are erosional marks indicating that the subsequent ice-flow shifted to a more southerly direction. In multiple striation localities, the very youngest have a due south orientation. My reconnaissance checks in the fall of 1982 show this to be a widespread occurrence. The eastward flow is interpreted to be a contemptuous event across all of northwestern Maine. The zone situated between evidence of north and southward flow is called an ice divide. This ice divide (Ross Lake Ice Divide) trends in a NE-SW direction and probably connects to the Quebec Ice Divide (Shilts, 1981).

In contrast, this situation may not be present in the eastern part of Aroostook county, where Genes and others (1981) presented a composite map showing the eastward flow shifting in a areal manner toward the south. Their map reports only rare multiple striation localities. However, Leavitt and Perkins (1935) on the basis of striation data and erratic distribution suggest that two flows crossed this region; one to the southeast and a second more to the south. Which of these contrasting views best explain the situation in eastern Aroostook County is problematic but in the following the more widespread distribution reported in Leavitt and Perkins is used. The ice-flow changes could be spatial, temporal, or both in nature.

The southern extent of localities showing southward ice flow over southeastward ice-flow is not known. However, Konoyer (1979) and Lowell (1980) reported, in the Millinocket-Lincoln area, southern flow over the southeastward indicators. Moreover, this region also shows scattered occurrences of eastward striations. To the east, Rampton and Paradis (1981) reported east-west drumlinoid ridges, eastward striations, and localties showing a southward swing in the Woodstock area of New Brunswick. Further the eastward indicators can be traced into Miramichi Bay. Gauthier (1979) also mapped strong early eastward indicators northeast of Miramich Bay. Thus the eastward flow can thus be traced from the St. Lawrence River near Quebec across northern Maine, and possibly south into central Maine and perhaps east into New Brunswick.

It seems that in regions south of the Quebec/Ross Lake ice Divide the flow chronology shows a dominate southeast ice-flow as indicated by lake alignment, drumlins and flutes that has superposed on it a weaker southward ice-flow. This shift has been reported in several widespread studies; the Kennebec Valley (Smith, 1964), Lincoln (Lowell, 1980b), Mount Desert Island (Lowell, 1980a), Bangor (Brady, 1982), Washington County (Ackert, 1982; Holland, 1981). Rather they can all be related to the same cause requires considerable further work but the hypothesis is advanced here for testing.

The key to this mess is to find a good reason for it. Two reasonable suggestions come to mind: 1) Following Grants (1977) hypothesis that the eastward flow originated in the early phases of the Wisconsin, then the subsequent north and south ice-flows represent the outflow from a independent late Wisconsin age ice mass. One consequence is that most of Maine and the Maritimes remained covered with independent ice during most of the Wisconsin. 2) Following Lowell's (in press) suggestion that all these features represent late Wisconsin events, then Laurentide ice invaded the region during the early part of the late Wisconsin but gave way to independent ice cap activity when cut off by a ice stream draing northeast in the St. Lawrence Seaway area. In either case, the relative sequence of events is the same, only the ages and causes differ. The last ice-flow moved outward from northcentral Maine and other centers.

I feel that an understanding of ice-flow events are necessary to correctly interpret the extent and influence of Laurentide ice in the Maritime Provinces, Maine and even southern New England. If Laurentide ice did not cross the St. Lawrence River into northern Maine, is the assumption that it flowed into the rest of New England still valid ? Perhaps the model of interconnecting ice masses better represents the late Wisconsin maximum ice configuration. Further, the study of ice-flow events provide information on amount and direction of ice activity just prior to deglaciation.

DEGLACIATION STYLE

Now that the manner of late glacial ice-flow has been left in confusion, it is time to consider the manner of deglaciation. The model common throughout southern New England is that of northward marginal recession. Although the minor details of that recession are still being hotly debated, the large scale view shows progressive northward recession with some measure of ice activity as the ice retreated. Moreover, in coastal Maine, extensive moraine sets demonstrate a complex interaction of retreating ice and rising marine waters (Smith, 1982; Thompson, 1982). However, above the marine limit well defined ice positions are not common (Caldwell, 1975; Kenoyer, 1979). Some small moraines, outwash heads, and repeating eskers segments show that the ice margin temporary paused at numerous locations. As yet, these locations have not been traced with any success from one valley to another.

A important consideration in northern New England is that in addition to an ice margin in the Gulf of Maine another ice margin developed to the east in the Gulf of St. Lawrence and third existed to the north in the St. Lawrence valley. Radiocarbon dates show that marine waters invaded the St. Lawrence Lowland a the same time they rose against the Maine coast. The Bay of Chaleur (just 200 km from eastern Aroostook County) opened somewhat earlier. Therefore, if the ice is receding northward from coastal Maine, eastward from the Gulf of St. Lawrence and southward from the St. Lawrence River, what happens in the middle ?

The Concept of Areal Thinning

In contrast to continuous retreating marginal model, the glacier may have simply stagnated over a wide area and downwasted in place. As the ice thinned, high mountains regions are first exposed as nunataks. With continued downward ice recession (as opposed to recession like a window shade) more and more area becomes exposed. The final ice occupied large lowlands. This deglaciation process is best documented in European studies, i.e. Garns and Bergerson, 1980; Seppala, 1980; and Marcussen, 1977. Ice draining into ice streams into Gulf of Maine, the Gulf of St. Lawrence, and the St. Lawrence River, might allow the highlands to become exposed first.

Borns and Calkin (1977) showed that ice thinned and separated over the Boundary Mountains, meltwater flowed around stagnant ice blocks east of the mountains while an ice margin dammed pro-glacial lakes west of the mountains (Shilts, 1981). A second dipstick showing early emergence is Mt. Katahdin. Although Caldwell and Davis (elsewhere in this volume for the latest round) still debate the amount of cirque activity on the east side of the mountain subsequent to emergence, abundant evidence shows ice filling the valleys around the mountain at about the 700 m level.

Lowell (in press) and Kite and others (1982) presented evidence from northern most Maine showing ice recession from the Notre Dame Mountain southeastward. This ice margin dammed a series of pro-glacial lakes that first drained through and then later northeast around the Notre Dame Mountains.

Considering these data and applying them in an areal thinning model requires that the large scale deglaciation of Maine be more analogous to a thinning pancake, rather than a shrinking dome. The rising sea level south, east, and north of Maine allowed large volumes of ice to be moved, via ice streams, from the interior of the ice mass to the margin without a significant retreat of the margin. Following this model, once the relative marine level dropped, it left a somewhat exhausted ice mass that had a wide spread distribution but had a flat profile that filled the lowlands. Final dissipation of a thick ice mass would not produce deposits with climactic importance. Because the activity on Mt. Katahdin is at most only limited, the region likely lies below the regional snowline after the peak emerged.

Support for this model comes from north-central Maine. In northern parts of this region, the striation data shows a strong, unified northward flow but very little evidence of late local divergence forced by topographic control. Once the ice stopped flowing into the Gulf of Maine, the Gulf of St. Lawrence, and the St. Lawrence valley, it had a flat profile that could not maintain even localized flow.

The deglaciation deposits, on the other hand, show considerable topographic control; extensive valleys choked with ice disintegration drift and stagnation moraine, lack of extensive or significant gravel deposits, and lack of defined ice positions.

HOW DOES THIS TRIP FIT INTO ALL OF THIS ?

All of this regional speculation is fine, but since we can't view it all in one day, just what are we going to see ? In order to accommodate trip logistics (i.e. the shortest road log) a route from Ashland to Rip Dam seems the best bet (Fig. 1). Unfortunately the trip trends parallel to the Ross Lake Ice Divide but is displaced just to the south of it. Therefore we will not see northward, good examples of southeastward striations, or cross-cutting locations, only the east-southeastward ice-flow indicators.

This field trip area is also located at the northern edge of the gravel zone. That is, very few valleys to the northwest contain appreciable or systematic gravel deposits. Ice separated into various basins and downwasted with the meltwater directed out of one or a succession of outlets. In this case limited meltwater reworked drift and deposited restricted kames, kame terraces, outwash fans, and outwash plains. The nature of two of these basins will be one focus of this trip (Stops 1,2,3,4,6,7 8,9).

Further, this region lies just on the southern end of mapping completed in 1982; thus most deposits and features within the area are not fully understood. Nevertheless, I believe the stops chosen exemplify the large scale deglaciation style sufficiently to warrant their examination; interpretations are subject to considerable improvement. Indeed discussion on this trip may prove the best catalyst.

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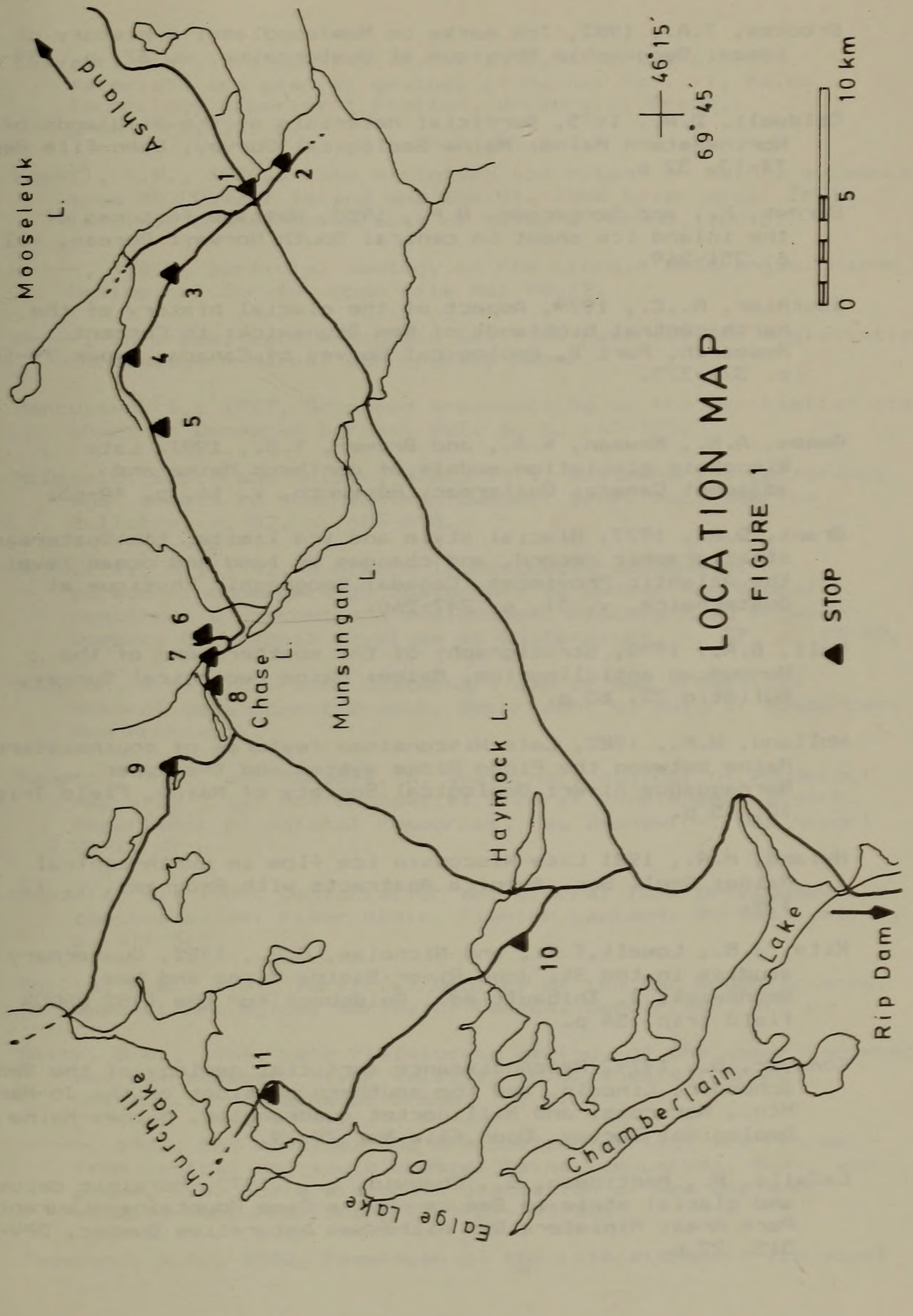

LOCATION MAP

FIGURE 1

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ROAD LOG

The following describes a route from Ashland to Rip Dam. The mileages are approximate and could change do to logging operations. Most of the trip is through the North Maine Woods; you must check in and out at Six Mile and Telos Gates. Some fees will be charged for private usage. The suggested stops may be modified to accommodate interests of the group, road changes, new discoveries, and acts of God.

Assembly point is Chris Hotel and Diner, on Route 163 just east of Ashland Maine. Starting time is 8:00 A.M. Stops during the trip will be in the Millinocket Lake, Spider Lake, and Churchill Lake U.S.G.S. 15′ quadrangles.

Mileage	
0.0	Leave Chris's parking lot, proceed west (left).
0.2	Turn right (N) onto Main Street at flashing light.
0.6	Turn left (W) at second flashing light.
1.4	Turn left (S) after crossing Aroostook River.
1.6	Pass Ashland Logging Museum.
1.9	Turn right (W) onto dirt road at North Maine Woods sign.
6.6	Keep left (SW).
6.9	Keep left (S) just after passing North Maine Woods gate.
7.3	Cross Greenlaw Stream.
15.8	Keep left (S) to cross Machias River.
29.6	Continue past Chase Brook Rd.
30.7	Pinkham Lumber Company Camp.
30.8	***Stop #1.*** Park well off road just after crossing Mooseleuk.

Downstream from the bridge is a 5 m thick exposure of gravel. The flat top of this deposit is at approximately 215 m.

31.2 Turn left (S) at 4 way intersection.

32.2 ***Stop #2.*** Turn left (E) into Rocky Brook gravel pit.

This active pit shows 5 m of bedded gravel. Dipping beds within suggest water flow toward 342 degrees. Moreover, Hall (1981, oral communication) noted the lack of Munsungan Chert clasts in the pit (the unit outcrops extensively to the north).

The flat topped feature is approximately 20 m above the present stream at 230 m. Faults, with up to 30 cm displacement, are present within the beds.

Observations from a pit within the core of a small esker some 6.5 km to the southwest show flow structures suggesting water flow to 115 degrees. Also noted were abundant Munsungan Chert clasts.

Interpretation: The lack of chert in the Rocky Brook Pit requires that the meltwater and debris were produced south of Norway Bluff. In contrast, the data from the esker pit are compatible with ESE ice flow and subsequent ice recession or downwasting. However, one way to accommodate the data from Rocky Brook is to have separate ice blocks disintegrating in adjacent valleys. Meltwater from one of these blocks could be supplied from Rocky Brook or from the south in the Aroostook valley. The delta may pre-date the Mooseleuk Stream outwash gravels (Stop 1).

33.1 Return to 4 way, continue straight (N).

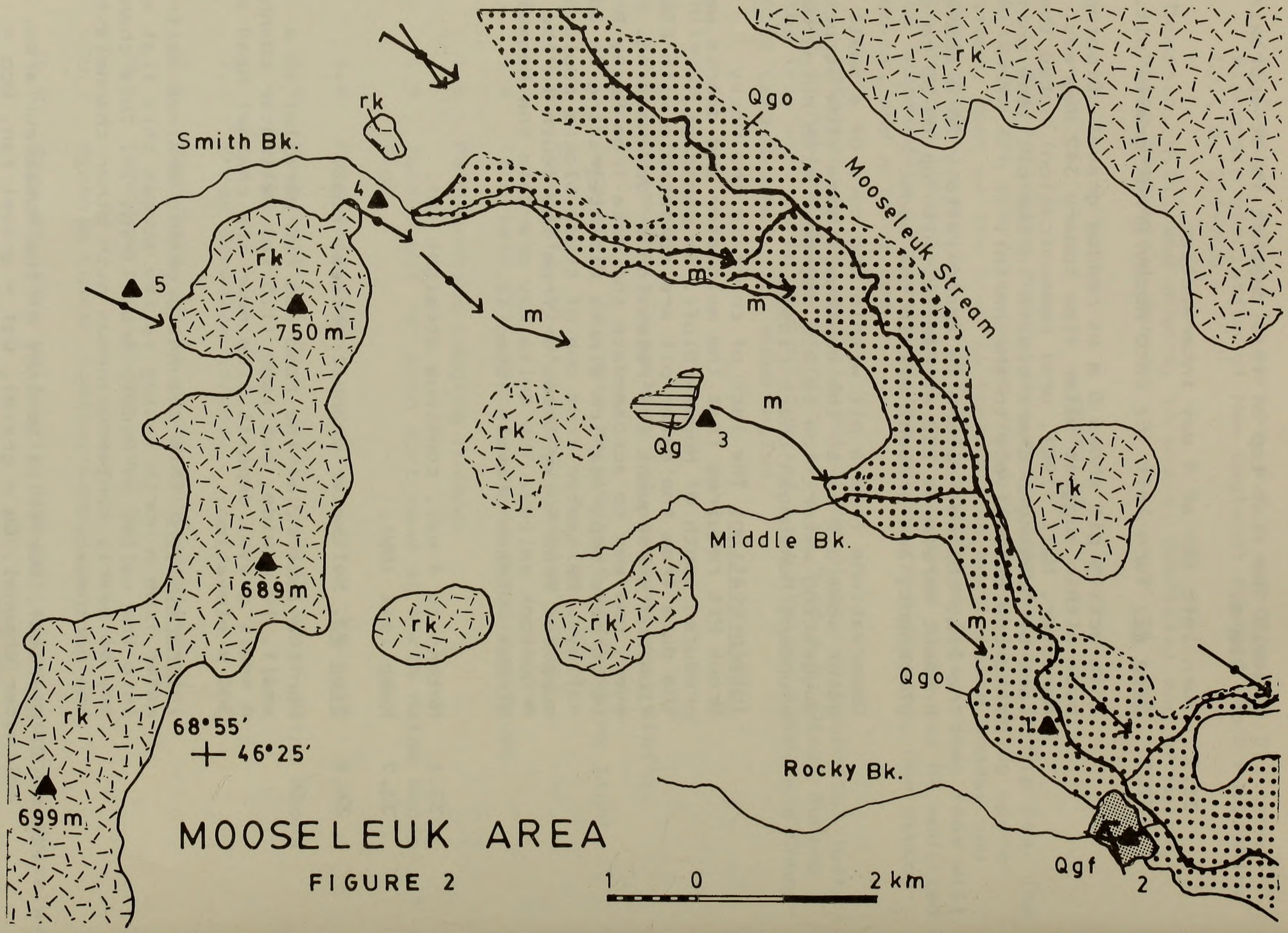
33.7 Keep left (NW).

36.1 ***Stop #3.*** Meltwater channel crosses road.

For the last .2 mi the road has run parallel to a small, 10 m wide, but long (1.5 km) meltwater channel. A small gravel deposit lies near the channel head at 300 m elevation.

Interpretation: This channel probably drained meltwater from a north facing valley across this flat and into the valley of Middle Brook (Fig. 2). This channel may be nearly contemporaneous with other channels to the northeast.

Figure 2. Overleaf. Surficial geology of the Mooseleuk area. m = meltwater channel, Qg = gravel, Qgf = gravel fan, Qgo = outwash, rk = rock. Striation localities = arrow with dot.



MOOSELEUK AREA

FIGURE 2

39.6 **Stop #4.** Striated rock and overlaying till.

The drift here displays two facies: the upper 30 cm is fissile and loose whereas the lower (up to 3 m thick) is compact, has a silty matrix supporting 20 per cent stones. Below the drift is banded volcanic bedrock displaying excellent stoss and lee forms and striation with an azimuth of 122 degrees. Below and north of this location we can see the 600 m wide gap through which Smith Brook flows.

Interpretation: The upper drift is probably colluvium derived from the underlying basal till. The striations are aligned with the valley trend but they are also nearly parallel with striations at the next stop. Smith Brook contributed meltwater and gravel into the Mooseleuk Stream from ice held behind (northwest) Mooseleuk Mountain.

41.8 Keep right (N) at Y.

41.9 **Stop #5.** Striated outcrop on south road side.

The outcrop south of the road shows a uniform direction of 115 degrees.

Interpretation: At this locality ice had to rise up at least 165 meters to pass over Mooseleuk Mountain. The close agreement of several striation localities (including stop 4) suggest that they were cut under an ice mass capable of ignoring at least 300 meters of relief.

43.0 Forest Service Camp.

47.0 Pass through Pell & Pell Camp.

47.2 Continue past road to south. This road provides access to the Archaeology site on Chase Lake.

47.9 Cross Chase Stream.

48.6 Access Road to Chase Lake. During the lunch stop park in the pit on north side of the road.

The campsite, located on the lake shore provides an excellent place for the black flies to have lunch.

Please note also the poorly exposed gravels in the pit. They are at 265 m elevation and are part of the nearly continuous gravels that ring Chase Lake at this elevation.

49.6 Turn right (N) just before crossing stream.

50.1 **Stop #6.** Striated outcrop and meltwater channel.

After leaving the main road we climbed above Sewall Deadwater (Fig. 3) to an elevation of 283 m. The outcrop on the roads north side exhibits an 107 degree trend. Stoss and lee features require ice moving east-southeast through this gap. Around the outcrop a small meltwater channel is cut into the valley side.

50.6 Return to main road, turn right (W), and cross stream.

50.7 **Stop #7.** Turn right (N) into Munsungan Brook gravel pit.

This pit, located within a small hill on the valley floor, shows highly variable stratification and undulating contacts. Rare Canadian Shield erratics have been noted here.

Upon leaving pit turn right (W)

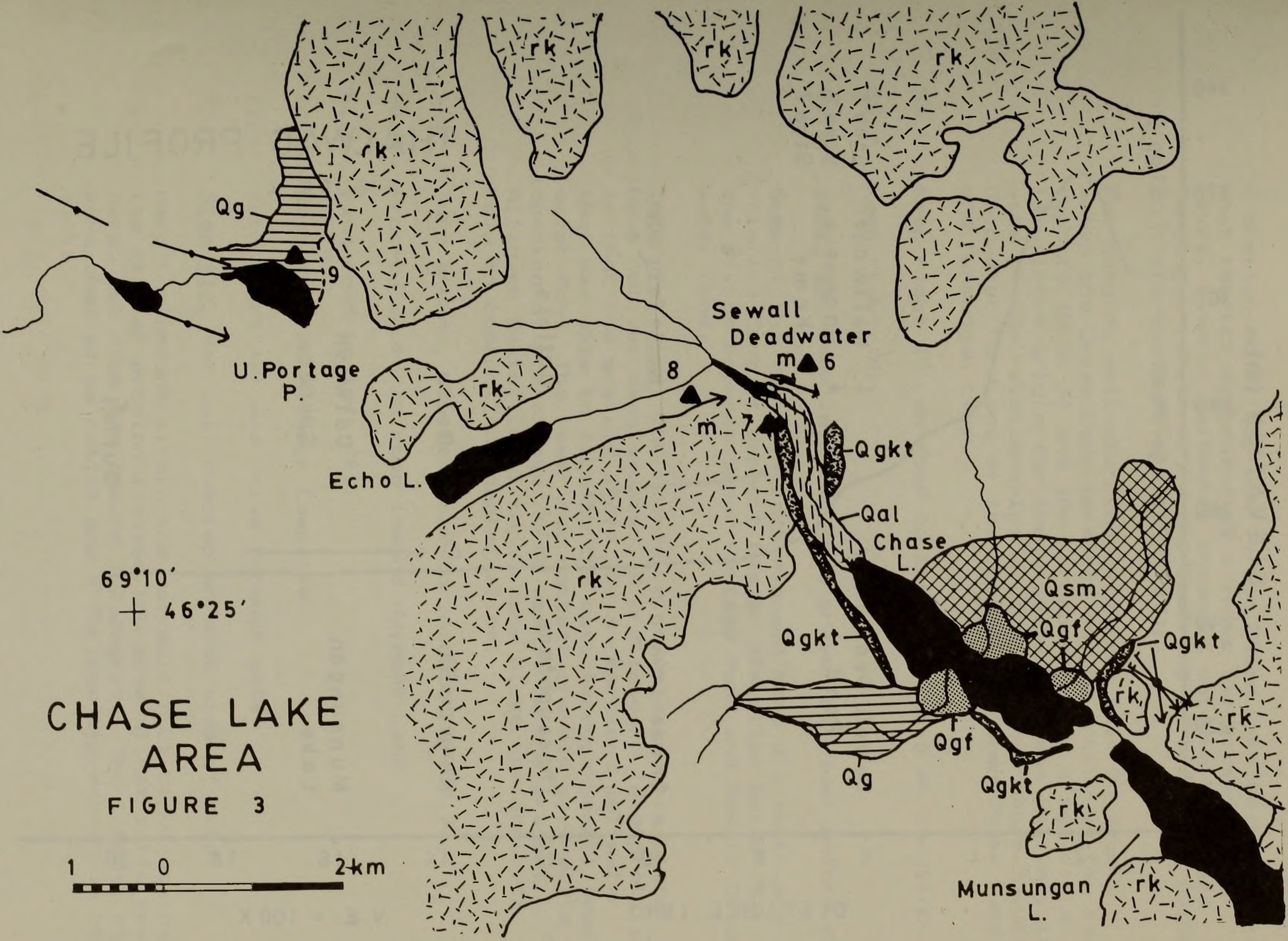
50.9 **Stop #8.** Meltwater channels.

This channel cuts into the south side of the Sewall Deadwater Pond gap at an elevation of 283 m. Several other channels also cut into this hillslope. From this location note the moderate relief to the north and west.

Interpretation: Stops 6,7, and 8. Hall (1970, p.42) noted the outwash surface and gravel from Upper Portage Pond (Stop 9) through Sewall Deadwater Pond, Chase Lake and into the Munsungan Lake Basin (Fig. 3). Further, he suggested the valley north of Echo Brook conducted meltwater from the Portage Ponds area into the Chase Lake basin. Due to the presence of outwash and delta gravels just above the present level of Munsungan Lake and the extreme depth of the lake (37 m), Hall suggested that stagnate ice blocks in the basin forced deposition along the ice margin.

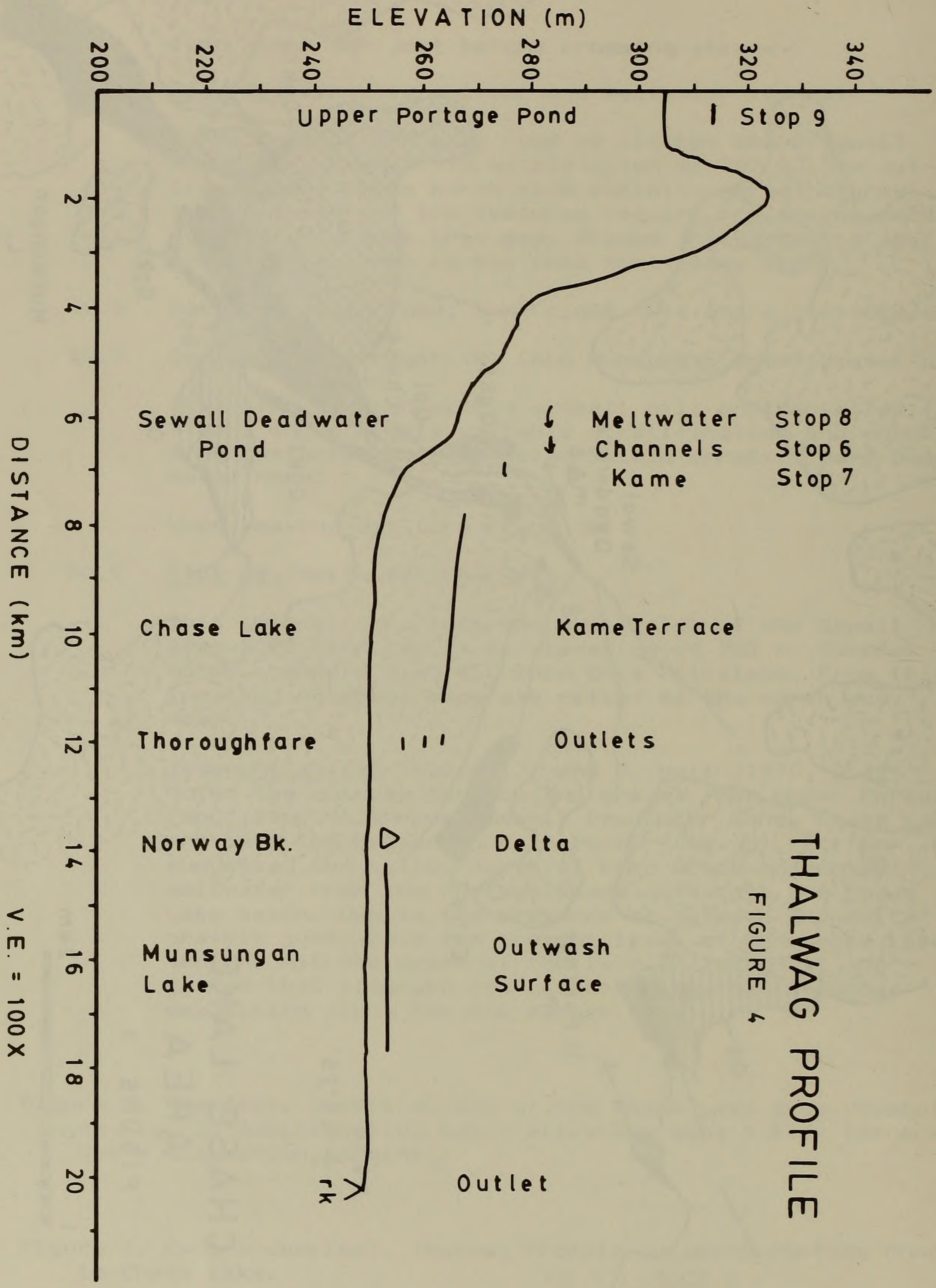
Figure 3. Overleaf. Surficial map of the Chase Lake area. Symbols as Fig. 2. Additionally, Qal = alluvium, Qgkt = kame terrace, Qsm = stagnation moraine.

Figure 4. Second overleaf. Thalwag Profile of Upper Portage Pond to Chase Lake.



CHASE LAKE AREA

FIGURE 3



THALWAG PROFILE

FIGURE 4

A similar model applies to the Chase Lake basin except that the ice stagnated 15 m above the present water level. Several meltwater channels between Chase and Munsungan Lakes record the lowering of meltwater paths to the present level.

The hanging meltwater channels less than 20 meters above the Chase Lake terraces may be active as the kame deposit (Stop 7) and the terraces formed (Fig. 4). A lacustrine origin for these terraces seems unlikely in view of the relationships of the channels above Sewall Deadwater Pond and of the channels between Chase Lake and Munsungan Lake.

53.7 Keep right (W) on road to Churchill Lake at junction.

54.7 Keep right (N).

56.1 ***Stop. #9.*** Turn left (S) into gravel pit just before camp.

Some of the variable beds exposed here dip southward. This ice contact deposit has an elevation below that of the divide between Upper Portage Pond and Sewall Deadwater Pond.

Interpretation: The extensive gravels in this basin have not yet been studied. A preliminary interpretation is that the gravels above 330 m represent meltwater that was able to flow to the east through Sewall Deadwater Pond. The lower ice contact gravels may relate to opening of a drainage route west into the present Allagash Basin. Local topography plays the dominate role in controlling deglaciation.

Turn around, proceed back to junction of 53.7.

60.5 Proceed south on road toward Haymock Lake.

61.6 Pass road to left (E).

70.8 Rest stop at Haymock Campsite.

72.1 Turn right (W) and drive through gate.

75.7 ***Stop #10.*** Rat tail outcrop on west side of road.

Hard inclusions within the volcanic rock stood against the glacial erosion leaving the several rat tails see here. Ice flow was toward 103 degrees. The largest has more than 10 cm relief and a curious depression in the tail.

Optional Side Trip

The following directions are provided to access whaleback outcrops near the Allagash Waterway.

0.3 Cross Smith Brook (nice waterfall under bridge).

2.6 Cross Soper Brook.

3.8 Keep left past road to right (E).

5.3 Continue north through 4 way junction.

9.1 ***Stop #11.*** Whaleback outcrops exposed in old pit west of road.

Removal of the thin gravel revealed several whaleback forms shaped from the fine grained rock. These forms, up to 2 m wide by 10-12m long and 2 m high display fraction cracks and striations in the range of 110 degrees. Several local variations are also present.

9.6 John's Bridge over Round Pond.

Interpretation: Stops 10 and 11. Considering the quadrangle wide distribution of uniform ice flow indicators in the range from 100 to 115 degrees, it seems reasonable to assign this to the last erosive ice to cross this area. This region is somewhat unique in that this is the only area in northwestern Maine that shows a single consistent flow over a wide region. To the north indicators of this flow have northward indicators superposed on them. In the regions south and southwest, Hyland (1981) and I have noted that the east-southeast flows in the range from 150 to 180 degrees on top.

One interpretation places this area between the influence of downdraw in the St. Lawrence Seaway and the Gulf of Maine. Toward either ice stream ice flowed in response to the lowering profiles. However, between these lowering profiles the ice is essentially motionless and thus records no subsequent movement. The role of thermal regime controlling the distribution of these features is not yet known.

9.6 John's Bridge Allagash Waterway.

Turn around proceed south. On to Rip Dam !

79.3 Return to road near Haymock Lake turn right (S).

81.4 Continue south past junction with Pinkham Road.

82.0 BEWARE ! Moose crossing area.

82.5	Road right (W) to Indian Pond.
88.6	Town line T6 R11 (yellow post).
89.8	Road AW-7 right (N).
91.9	Cross Chamberlain Bridge. Note Mt. Katahdin to left (S).
92.0	Turn left (S) at parking lot.
95.1	Pass through North Maine Woods Telos Gate.
99.0	Enter Telos International Airport.
100.6	Telos Camp.
108.0	Pass west entrance Baxter State Park on left (E).
108.4	Keep left at Harrington Lake Dam Campsite.
115.2	Turn right (W) onto tar road after crossing the West Branch Penobscot River.
116.5	Turn right (NW) onto dirt road at Prays Camp sign.
116.9	Prays Camps, Ripogenus Dam; end of trip.