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DEPARTMENT OF CONSERVATION
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Title: Ice Flow and Deglaciation: Northwestern Maine (49th Annual Friends of the Pleistocene Guidebook)

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49th ANNUAL FRIENDS OF THE PLEISTOCENE GUIDEBOOK

ICE FLOW AND DEGLACIATION: NORTHWESTERN MAINE

May 23,24,25, 1986

Fort Kent, Maine

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INTRODUCTION

The purpose of the 49th Friends of the Pleistocene meeting is to discuss some of the recent work in northern Maine and its place in a regional setting. The Maine Geological Survey has generated much of that work through support for mapping and other investigations in the area. Most of the information presented in this guidebook is taken from Ph.D. dissertations by Lowell (1986) and Kite (1983) and from M.S. theses by Kite (1979), Lowell (1980), Becker (1982), and Halter (1985). Many outcrops are too far into the North Maine Woods to visit on this trip, but we have assembled a sequence of stops (Figure 1) that shows the evidence relating to ice-flow history, stratigraphy, and deglaciation of an area that is important in any correlation of events between southern Quebec, Atlantic Canada, and New England.

Initially, our understanding of events in northern Maine progressed rapidly from knowing nothing to knowing it all. However, as we continued to look at some aspects of the local glacial geology, we found ourselves moving once again to the know nothing stage. We believe this stage is a good place to be for this meeting because we can present the Friend with what we believe (or once believed) and they can tear it apart with our encouragement. We genuinely hope that you will raise questions and give suggestions that will allow us to better reconstruct the Quaternary geology of the region.

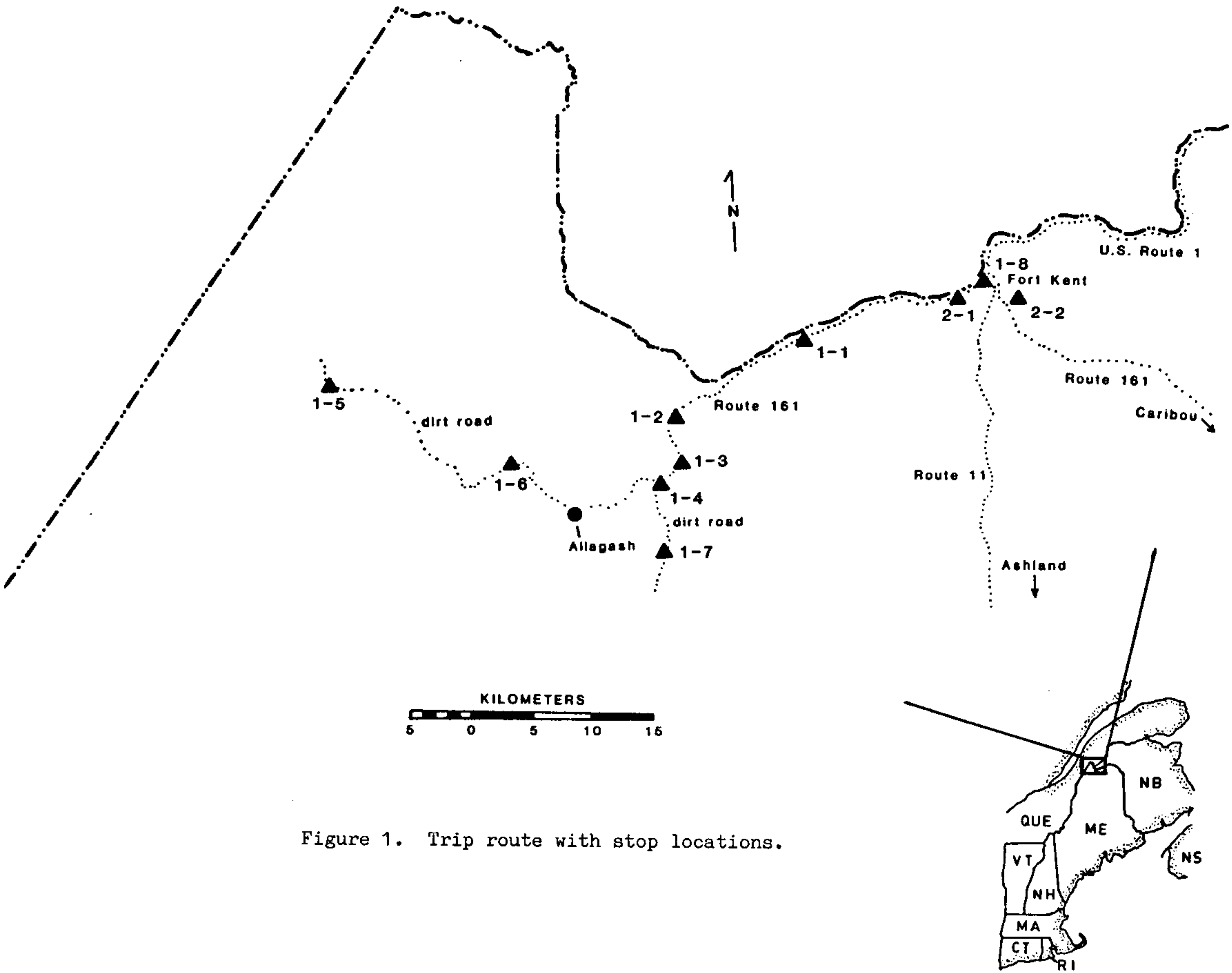


Figure 1. Trip route with stop locations.

TRAVEL DIRECTIONS FOR DAY 1

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
0.0	0.0	Crocker Hall, University of Maine at Fort Kent. Assemble at 7:30 A.M. Proceed to Rt. 11.
0.35	0.35	Turn right (north) on Rt. 11.
0.55	0.2	Turn left (west) at triangle.
0.6	0.05	Turn left (west) on Rt. 1. Proceed through downtown Fort Kent.
1.0	0.4	U.S. Rt. 1 ends. Go straight (west) on Rt. 161. Do not cross bridge to Clair, New Brunswick.
6.5	5.5	St. John/Fort Kent town line.
9.0	2.5	Cross railroad tracks.
11.4	2.4	Cross Wheelock Brook, then pull off to side of Rt. 161. Park and walk to outcrop near railroad tracks.
	STOP 1-1: WHEELOCK BROOK LOCALITY (Striated Pavement)	
		Return to vans. Proceed west on Rt. 161.
13.45	2.05	St. Francis/St. John town line. Cross railroad tracks.
17.65	4.2	St. Francis School on right.
20.25	2.6	Note terrace on left.
20.35	0.1	Note Rankin Rapids picnic and camping grounds on right.
	STOP 1-2: RANKIN RAPIDS (Stratigraphy)	
22.75	2.4	McLean Brook pit on left.
22.85	0.1	Cross McLean Brook.
22.95	0.1	McLean Brook section on left. Park on right side of Rt. 161. Be careful crossing road.
	STOP 1-3: MCLEAN BROOK LOCALITY (Stratigraphy)	
		Return to vans. Continue west on Rt. 161.

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
23.85	0.9	Janet's Quick Lunch (and gas station).
24.1	0.25	Golden Rapids Subsection B on left. Park on right side of road. Be careful crossing road.
	STOP 1-4: GOLDEN RAPIDS LOCALITY (Stratigraphy)	
	0.6	Return to vans. Proceed west on Rt. 161.
26.4	2.3	Allagash/St. Francis town line.
28.5	2.1	Cross Negro Brook.
29.1	0.6	Gardner's sand and gravel pit on left.
29.7	0.6	Cross Allagash River on one lane bridge.
30.3	0.6	Veer right at fork in road (stay on Rt. 161).
32.9	2.6	Turn right. Cross St. John River on one lane bridge (stay on Rt. 161).
33.75	0.85	Turn left. Cross Little Black River on one lane bridge (stay on Rt. 161).
35.0	1.25	End of paved road.
36.0	1.0	Note old Walker Brook campground on left.
36.9	0.9	Turn right.
37.1	0.2	Stop at North Maine Woods Dickey checkpoint.
37.25	0.15	Turn right onto St. Pamphile Road. Follow sign to Big Black/Morell Shed and Camp 106. Stay on St. Pamphile Road, which generally heads northwest and is marked by yellow mile markers.
43.4	6.15	Road curves to left. Stay on St. Pamphile Road, which now generally heads west.
47.3	3.9	Mile marker 10.
47.7	0.4	Turn left at fork onto less-used road.
48.0	0.3	Road curves sharply to right (north). This curve is the old rabbit turn.

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
48.1	0.1	Park van in front of pit.
	STOP 1-5: RABBIT TURN (Till Exposure)	
		Return to vans. Proceed north on old road.
48.3	0.2	Turn right on road. Return to Dickey.
48.6	0.3	Note intersection passed at mile 47.7. Proceed back to Dickey checkpoint.
59.3	10.7	Pass through Dickey checkpoint on return to Allagash.
60.1	0.8	Note Walker Brook campsite.
61.95	1.85	Park on right side of road.
	STOP 1-6: DICKEY DELTA (Landform)	
		Return to vans. Continue east on Rt. 161.
62.3	0.35	Cross Little Black River.
63.1	0.8	Cross St. John River.
66.15	3.05	Cross Allagash River.
71.55	5.4	St. Francis/Allagash town line.
72.75	0.7	Janet's Quick Lunch. Turn right (south) onto gravel road.
72.5	0.25	Turn right at fork.
72.55	0.05	Follow Togue Pond sign.
72.7	0.15	North Maine Woods St. Francis checkpoint.
74.6	1.9	Be careful at small washout (1985).
77.0	2.4	Cross unnamed tributary of Lewis Brook.
77.05	0.05	Note striated outcrop on left.

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
77.1	0.05	Walk back 70 meters north to striated outcrop. The vans will proceed to turn around.
		STOP 1-7: TOILET BOWL LOCALITY (Striated Pavements)
77.2	0.1	Van turn around spot.
77.35	0.15	Reboard vans, heading north. Return to St. Francis checkpoint.
81.7	4.35	St. Francis checkpoint return to Rt. 161.
81.95	0.25	Turn right on Rt. 161 (at Janet's Quick Lunch).
82.85	0.9	McLean Brook exposure. Continue east on Rt. 161.
104.8	21.95	Rt. 161 merges with U.S. Rt. 1 in Fort Kent. proceed through downtown Fort Kent.
105.1	0.3	Bear right. Stay on Rt. 1 east.
105.2	0.1	Bear left. Stay on Rt. 1 east at triangle.
105.35	0.15	Turn left, at sign for Fort Kent Blockhouse. Do not cross bridge over the Fish River.
105.4	0.05	Park in blockhouse parking lot.
		STOP 1-8: FORT KENT BLOCKHOUSE (Summary and Discussion)
		Return to vehicles. Go west on one-way street (Blockhouse Rd.).
105.5	0.1	Turn left at first street (Pleasant St., but there was no sign in July 1985).
105.55	0.05	Cross Rt. 1 on Pleasant St.
105.6	0.05	Turn left (south) onto Rt. 11, at stop sign.
105.75	0.15	Turn left at the University of Maine. Proceed to Crocker Hall.
106.0	0.25	Park near Crocker Hall.

END OF DAY 1

DESCRIPTIONS OF STOPS FOR DAY 1

STOP 1-1 WHEELOCK BROOK (Striated Pavement)

DESCRIPTION AND INTERPRETATION

This pavement of Seboomook Formation bedrock displays one uniform set of striations, which have a trend of 150/330 degrees. Several 10 to 15 cm high stoss-and-lee forms on the outcrop surface indicate eroding ice moved toward the northwest (330 degrees). This and 272 other outcrops delimit an area affected by northward-flowing glacial ice. This area covera at least 7000 square km in northwestern Maine (Figure 2) and is contiguous with a much larger area displaying northward ice-flow indicators in Quebec and New Brunswick. In Maine, the strength of these northward ice-flow indicators generally decreases toward the southeast. This distribution of ice-flow indicators of various strengths is thought to have formed beneath a late-glacial ice mass whose flow divide shifted to the southeast in response to downdraw in the St. Lawrence River area (Lowell and Kite, 1986).

STOP 1-2: RANKIN RAPIDS (Stratigraphy)

DESCRIPTION

The sections are exposed on the east bank of the St. John River in the town of St. Francis, 3 km north of McLean Brook. The surface here is terraced at about 180 m elevation but a second higher terrace lies above the surface level of Route 161. The Rankin Rapids picnic area lies directly above the sections and provides access to the river level. Genes and others (1981) noted the stratigraphy here as stratified boulder to pebble gravel, which overlies stratified sand and silt. The gravels contain granite gneiss clasts. The lowest unit Genes and others describe is a compact, silty clayey, dark gray till. Genes and others report a two dimensional fabric in the diamicton with a strong maximum at 90 degrees. Newman and others (1985) also report on the stratigraphy at Rankin Rapids.

INTERPRETATION

This stop has been included to provide an example of the gray compact diamicton and to give the Friends a sampling of the stratigraphic units exposed above diamicton units. The till appears to be correlative with several other diamictons exposed nearby. This unit may represent the invasion of eastward moving ice of Laurentide source. However, the age of the diamicton and the overlying stratified units is unknown.

STOP 1-3 MCLEAN BROOK (Stratigraphy)

DESCRIPTION

McLean Brook flows between two exposures of Quaternary sediments along the southeast side of Route 161. The general topography and the locations of the exposures are shown in Figure 3. The northeastern exposure consists

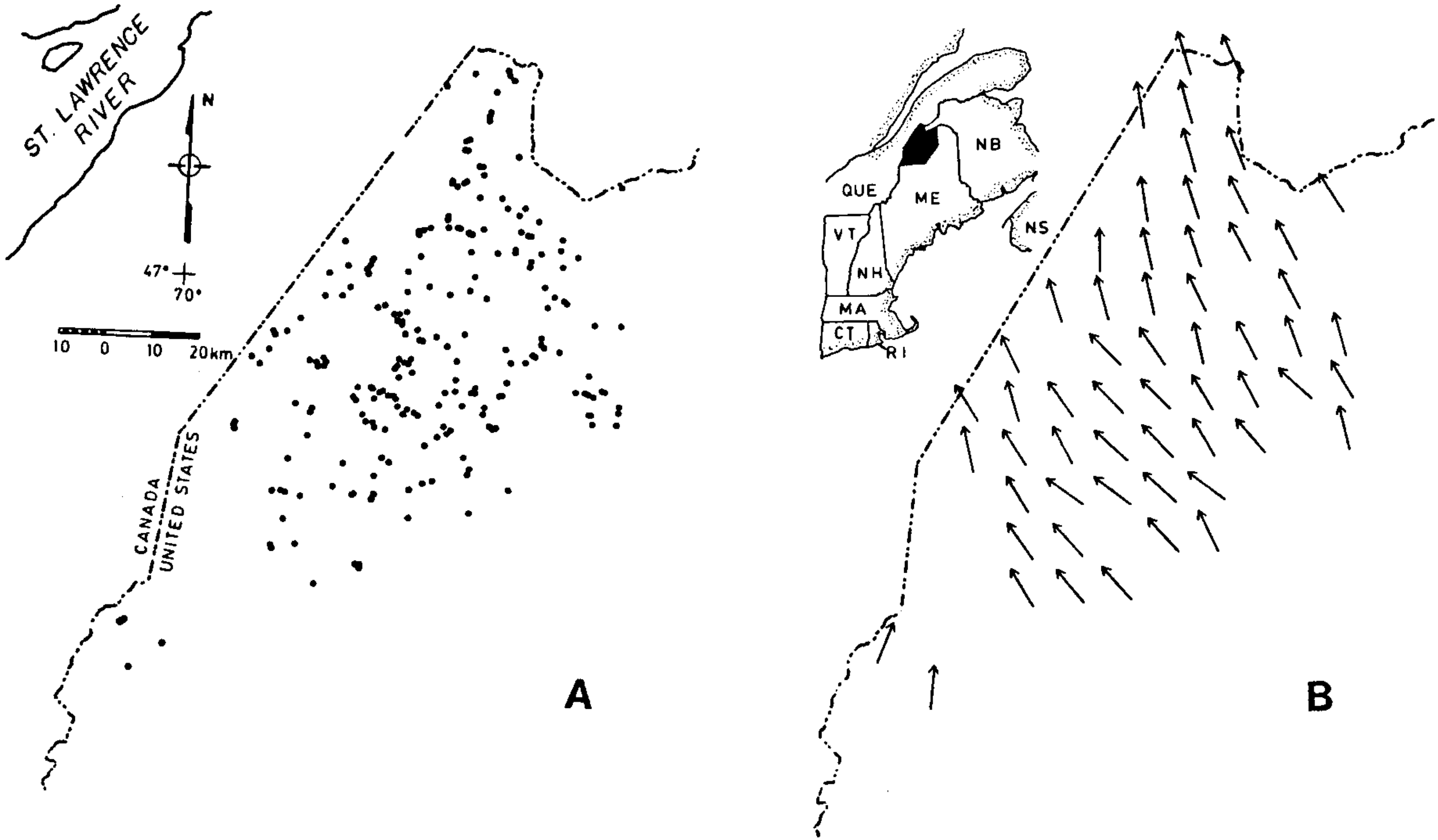


Figure 2. A) Distribution of outcrops showing evidence of northward flowing ice, B) vector means of striation sets found on those outcrops.

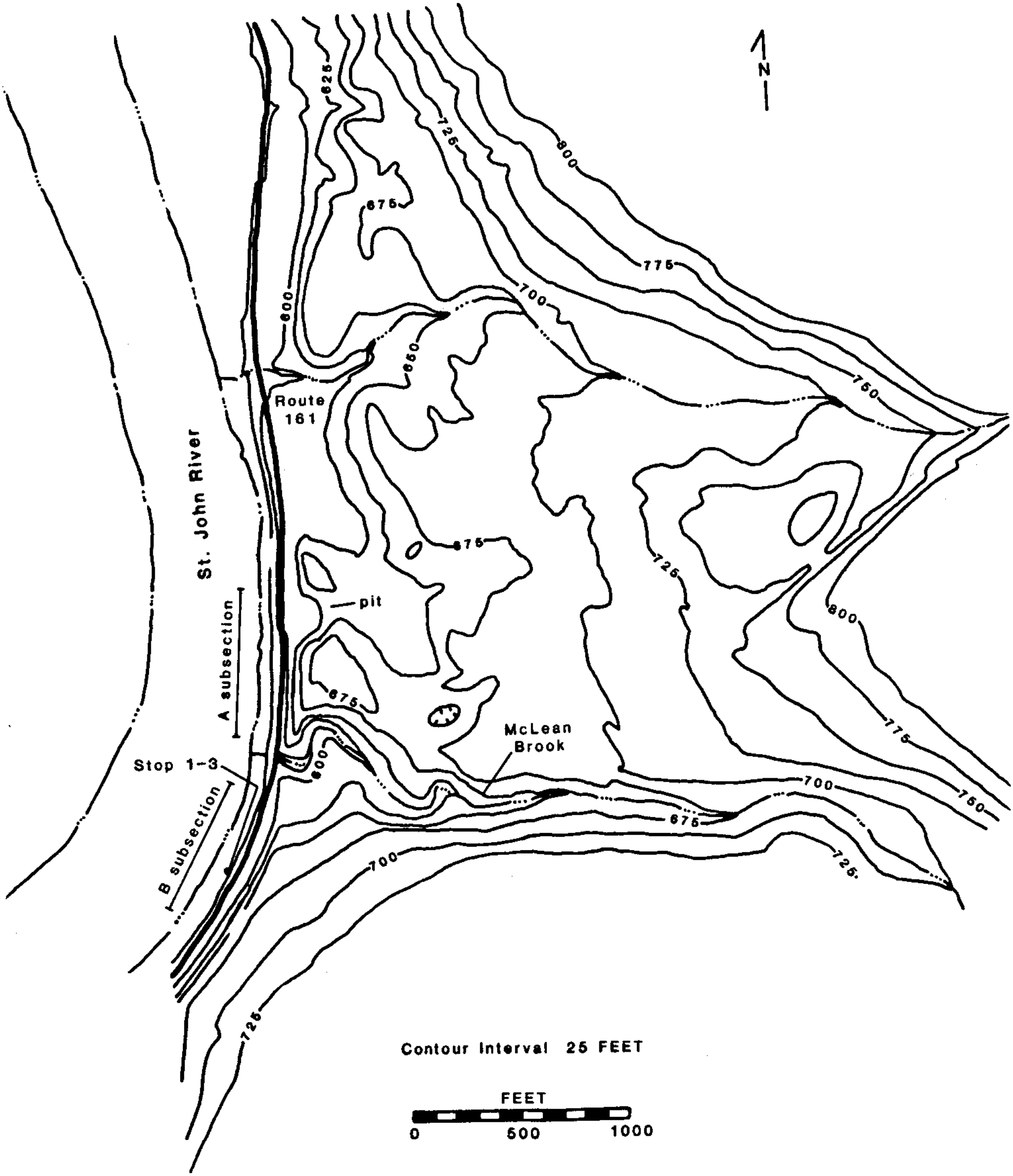


Figure 3. Local topography and setting near McLean Brook (Stop 1-3).

primarily of stratified drift, whereas the southwestern exposure displays stratified drift above and below two diamicton units.

Genes and Newman (1980, p. 186) described the stratified drift and diamicton as distal deposits of a recessional moraine composed of Van Buren till and outwash. Becker (1982) studied and described the southwestern section; our interpretations draw heavily from his observations. The stratigraphic relationships between units in the exposure can be seen in Figure 4. Figure 5 shows some of the detailed descriptions reported by Becker at this locality.

INTERPRETATION

The McLean Brook exposures display a stratigraphy similar to that observed at the two Golden Rapids exposures (Stop 1-4). Although the Golden Rapids exposures have generated considerable controversy (Genes and others, 1981; Lowell and others, 1983; Genes and Newman, 1983), we visit this locality because its counterpart, the riverside exposure at Golden Rapids, is badly slumped (as of July 1985).

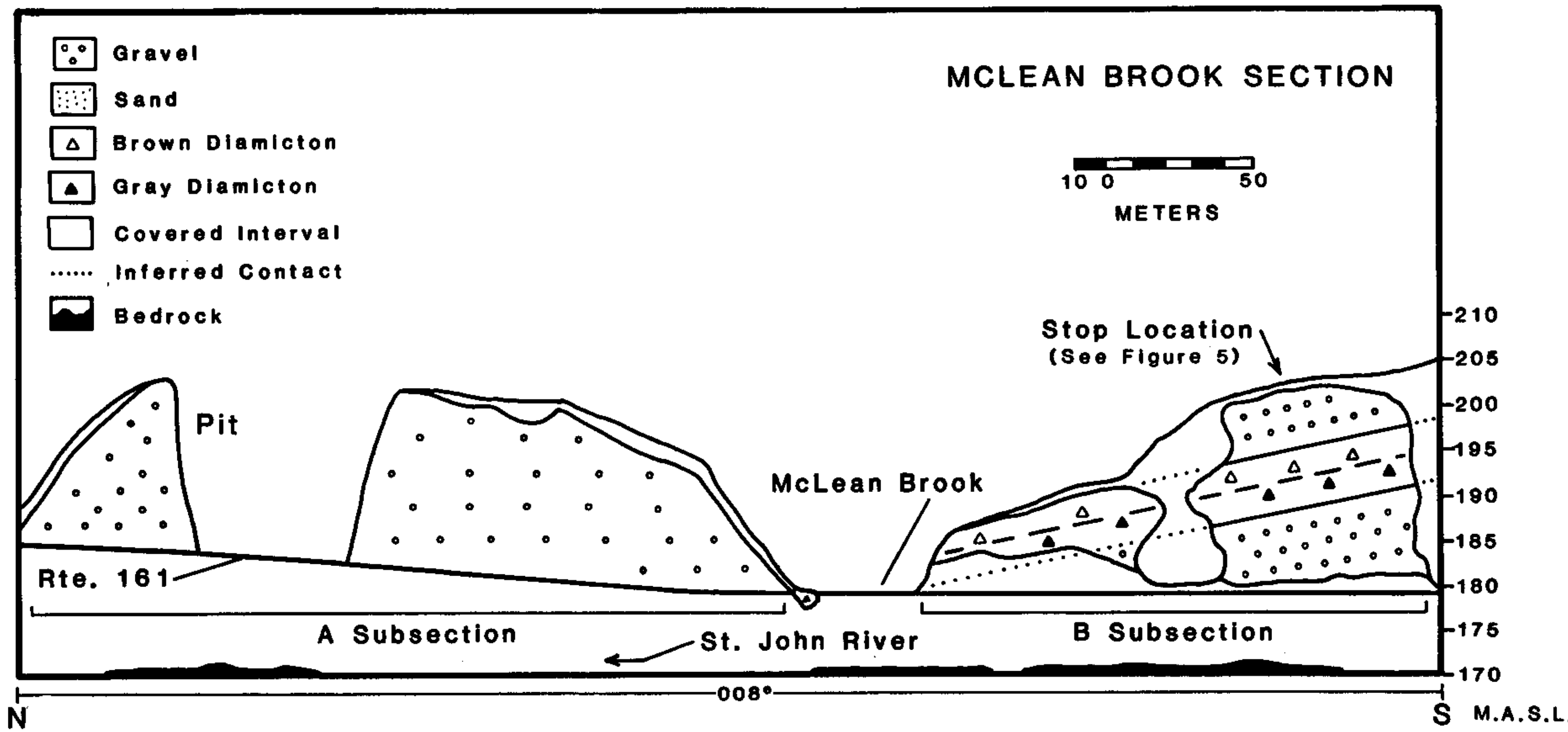
One interpretation (Becker and others, 1982; Lowell and others, in press) suggests the units record the following sequence of events: (1) deposition of fluvial gravels (unit 1); (2) deposition of the sandy-silt-matrix diamicton (unit 2) beneath an eastward-flowing glacier; (3) followed directly by deposition of the silty-sand-matrix diamicton (unit 3) beneath a northward-flowing glacier; and (4) subsequent ice recession allowed meltwater to flow northwest, down the valley of McLean Brook, and interact with remnant ice masses in the St. John River valley (producing unit 4).

One important aspect to consider here is the nature and significance of both diamictons (units 2 and 3). Are these diamictons different facies of one glaciation, or are they basal tills laid down under different basal conditions? Did mass wasting or ablation play a role in the formation of these diamictons?

STOP 1-4 GOLDEN RAPIDS (Stratigraphy)

DESCRIPTION

The Golden Rapids exposure may be the most studied, yet least understood, section in northwestern Maine. Several groups have looked at the exposure and the surrounding area for various reasons in the last decade. The Corps of Engineers conducted drilling in the area to determine its aggregate resource potential. Genes and Newman (1980) led a field excursion to the exposure and reported on its stratigraphy, as did Kite and others (1982). Lowell (1980) reported on portions of the section and Mahar (1982) investigated the color differences between the sediments. In 1981, the Maine Department of Transportation dug test pits above the exposure in a study of potential routes along which to relocate Route 161. Becker and Lowell (Becker, 1982; Becker and others, 1982; Lowell and others, in press) worked on the stratigraphy of the Golden Rapids and other nearby sections. Brewer and others (1983) attempted to place the stratigraphy of this exposure in a regional context by correlating the diamicton units exposed here to those at Hammond Brook, 75 km



July 1981

Figure 4. View looking east of stratigraphic relationships between units at McLean Brook (Stop 1-3). See Figure 3 for location of subsections A and B.

MCLEAN BROOK

Location: St. Francis, ME USGS 15' quadrangle. On road cut above the west bank of the St. John River, 75 m upstream from the confluence with McLean Brook. UTM 5052E 52183N. Elevation 207 m.a.s.l. Described in July 1981.

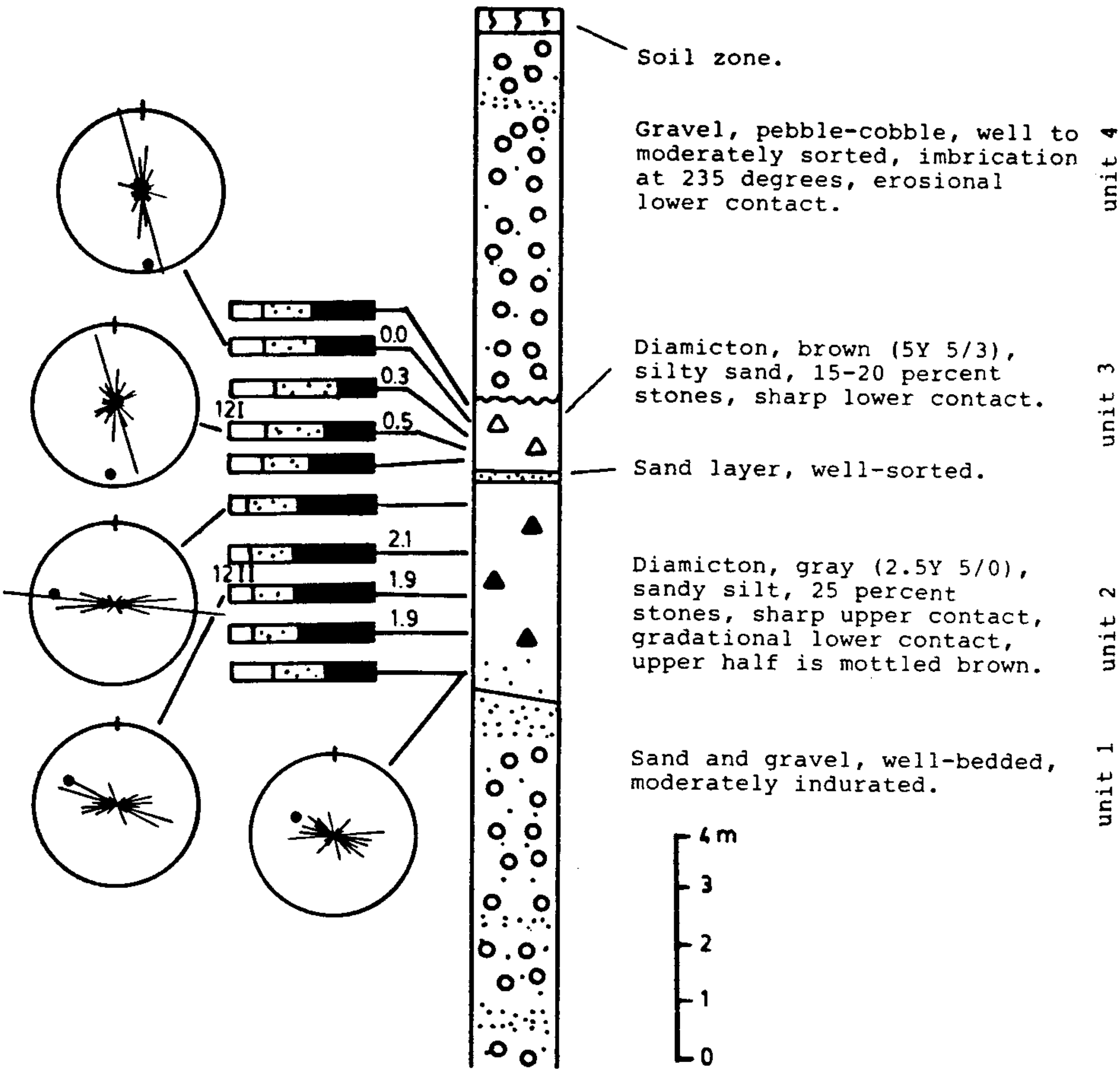


Figure 5. Detailed description of one section at McLean Brook. Location of section on Figure 4. The bars on the left of the column represent the percentage of gravel (open), sand (dotted), and mud (solid). The number to the right of the bar is the percent of carbonate. The rose diagrams show the orientation of stones (A:B = 1:2). Circle represents 5 stones. Dot in circle is the lower hemisphere stereo-net projection of the 3-D eigenvector.

to the east. However, all of these works have reached quite contrasting views and no consensus has been reached on the interpretation of these exposures. One could say that we have looked and looked at the exposures, but are still not sure if we see them clearly.

The Golden Rapids locality consists of two separate subsections, designated A and B (Genes, oral communication, 8 July 1981). The topography near Golden Rapids and the locations of the subsections are shown in Figure 6. Subsection A consists of natural exposures on the St. John River downstream (east) from Wiggins Brook. Slumping and bank erosion have obscured the original section described by Genes and Newman (1980) but have improved several other sections closer to Wiggins Brook. Because Genes's original subsection A is poorly exposed, we have substituted the stop at McLean Brook to demonstrate a typical "two-till" sequence in the St. John River valley.

The B subsection, located south of Route 161 and west of Wiggins Brook has also changed, in this case because of road construction. During the reconstruction of the culvert over Wiggins Brook in 1984, a large portion of the eastern part of this exposure was exposed for the first time, as shown in Figure 7. Figure 8 shows an overview of both subsections.

INTERPRETATION

One topic that should generate considerable interest is the correlation of units between the McLean Brook exposure (Stop 1-4) and the roadside exposure at Golden Rapids. This exercise carries with it many of the same problems as trying to correlate units between the A and B subsections less than 250 m apart, or correlation with the Hammond Brook sections 75 km to the east! At least three possibilities have been suggested. We present them for discussion because each carries different implications for the regional stratigraphy.

In the first possibility (Figure 9a), the lower silty diamicton at McLean Brook is correlated to the uppermost diamicton in the Golden Rapids roadcut. This interpretation implies that most of the stratigraphy exposed in the roadside section (subsection B) is older than the last ice advance.

The second possibility (Figure 9b) is a correlation of the lowest diamicton at McLean Brook with the diamictons exposed on the western end of the roadside exposure at Golden Rapids. Such a correlation requires that most of the units exposed at Golden Rapids were deposited during the last glaciation.

The third possibility is for all of the units exposed on the Golden Rapids roadcut to lie stratigraphically above all of the diamictons at McLean Brook (Figure 9c). This interpretation suggests that deposits of the last glaciation are expoaed in the roadside cut and that a nonglacial interval occurred between deposition of the diamictons at McLean Brook.

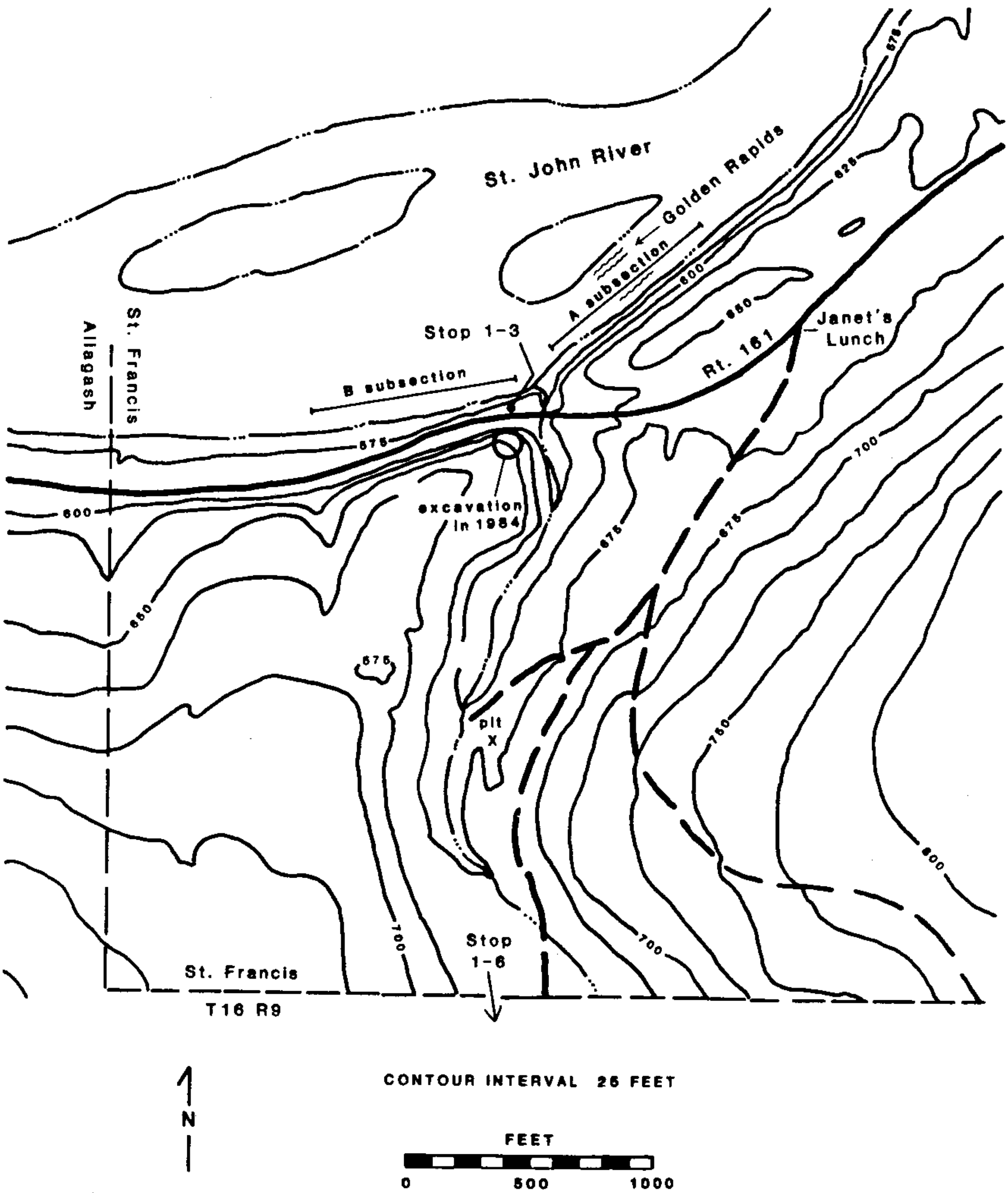


Figure 6. Local topography and setting near Golden Rapids (Stop 1-4).

NEW EXPOSURE AT GOLDEN RAPIDS: 1985

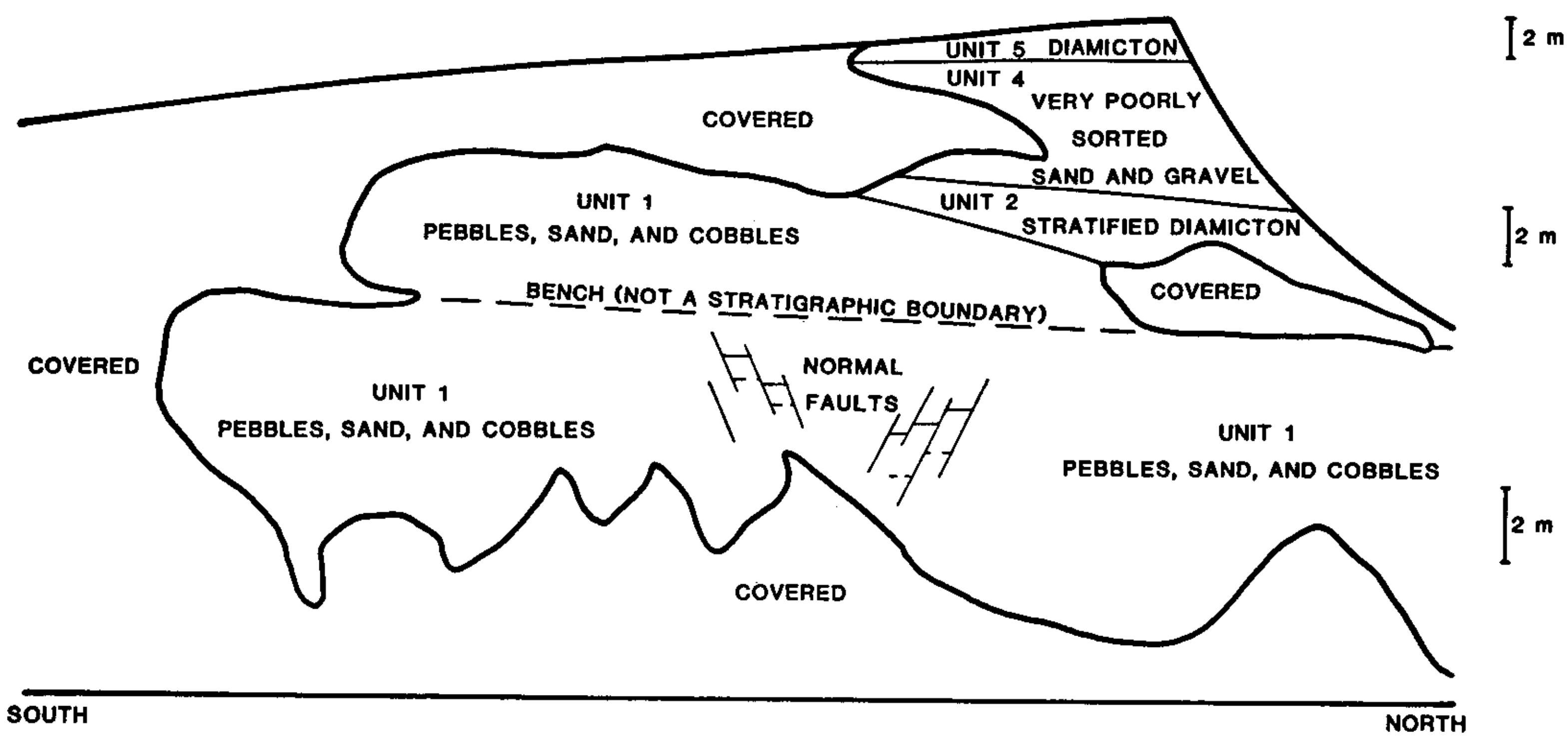


Figure 7. New exposure at Golden Rapids, July 1985. Viewed across Wiggins Brook from Rt. 161, looking west. Horizontal scale = vertical scale. Scale varies because of distortion on photographic base for this figure.

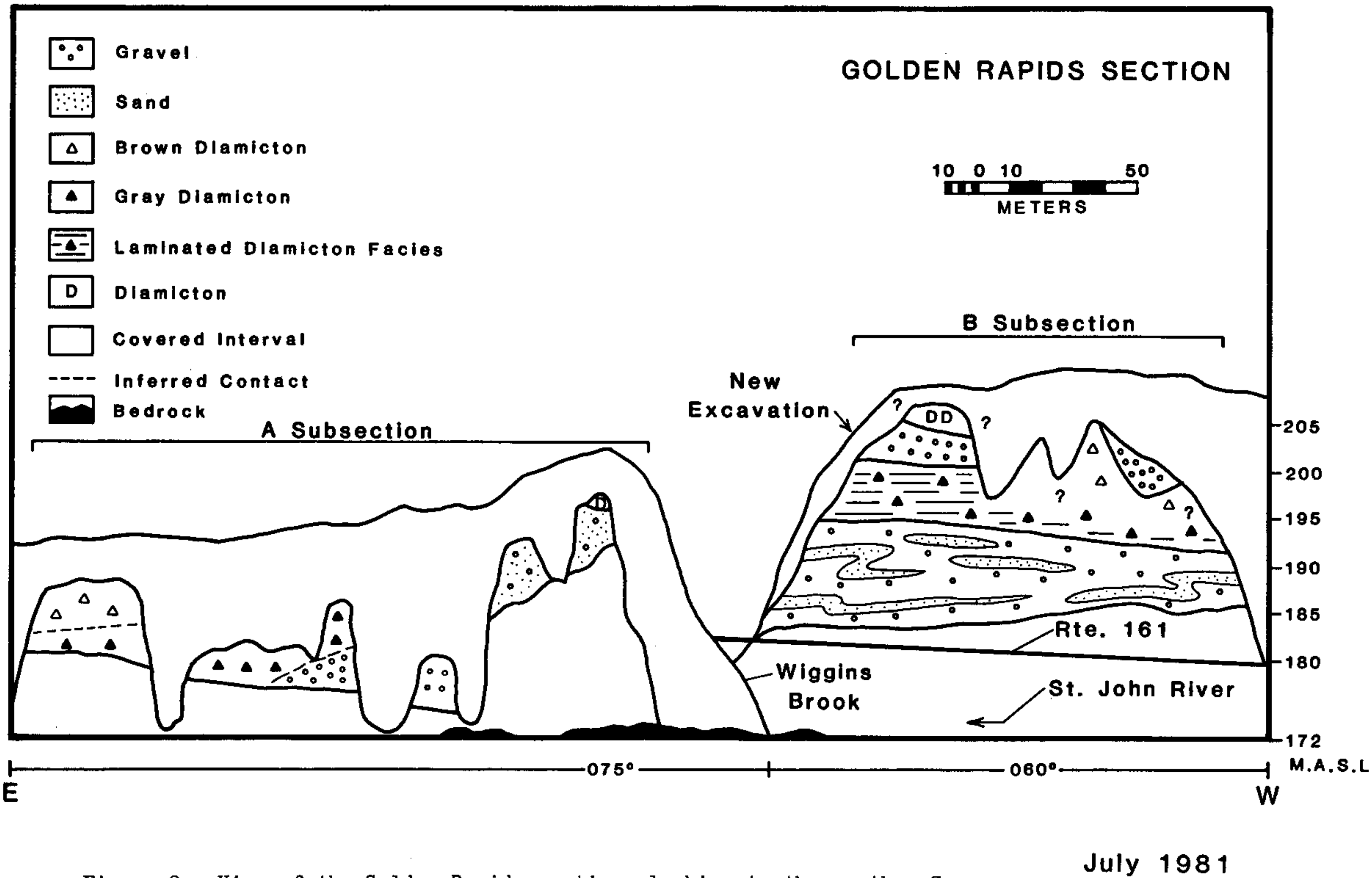


Figure 8. View of the Golden Rapids sections looking to the south. See Figure 6 for locations of subsections A and B.

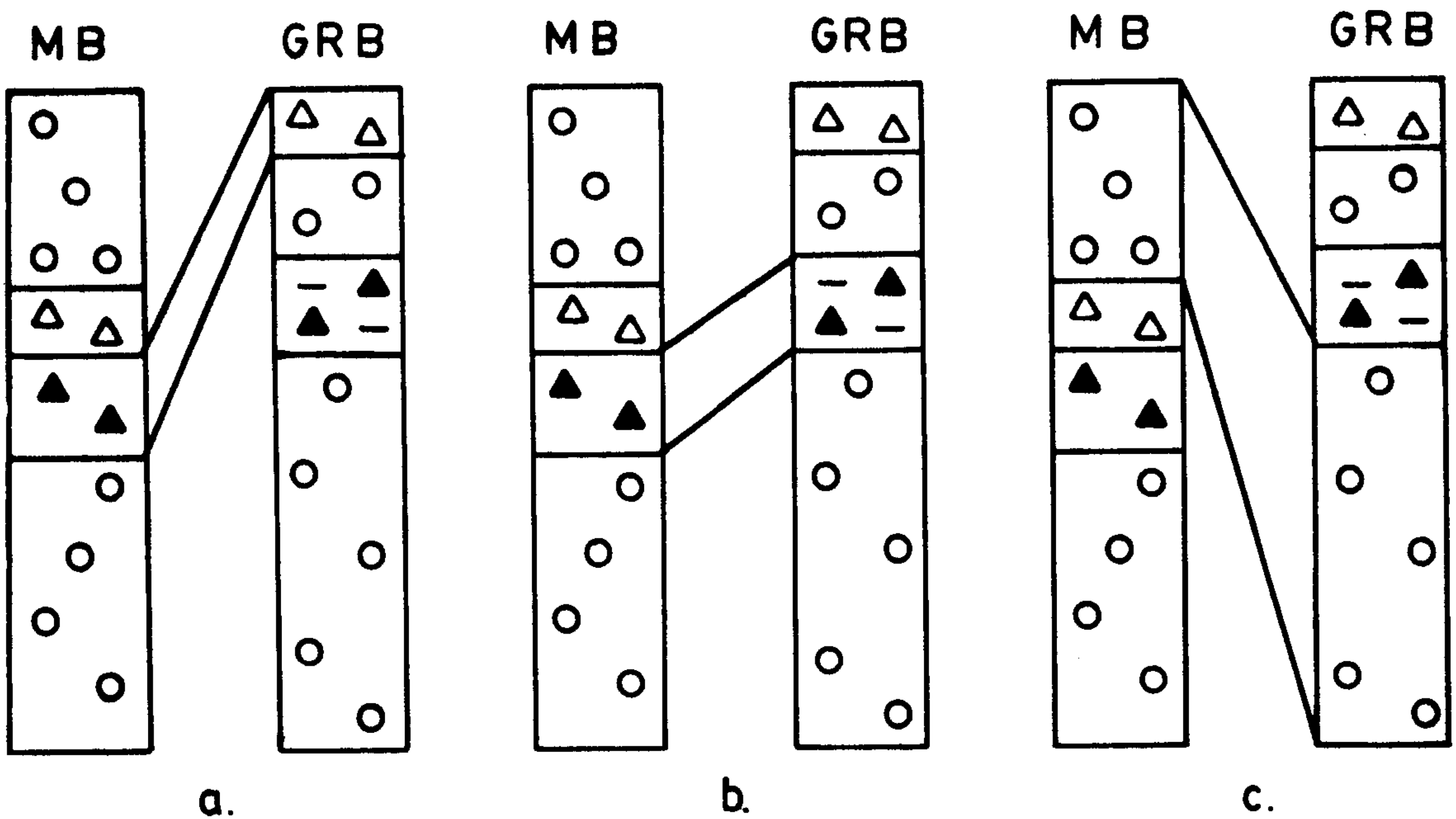


Figure 9. Possible correlations between McLean Brook (MB) and Golden Rapids B (GRB).

STOP 1-5 RABBIT TURN PIT (Deformation till and basal till)

DESCRIPTION

The Rabbit Turn pit (Figure 10) lies at the extreme southeastern end of a low ridge underlain by the Ordovician-to-Silurian Depot Mountain Formation. Dark gray to black slate of this formation interfingers with equal or greater amounts of gray, slate-chip rich graywacke (Roy, 1980). Roy (1980) reports that bedding in this pit generally strikes at 62 degrees (N 62 E). Our measurements in 1985 ranged from 50 to 104 degrees (N50E to N76W). Occasionally, material from the pit is used as road material, so the exposures may be quite different than when field trip preparations were being made in July 1985.

The unconsolidated material in the pit consists of two or three diamicton units. The lowest unit is a gravelly diamicton, largely composed of angular fragments of local bedrock, and having 3 percent or less clay (Table 1; samples SK-85-366B, TL-85-348B, TL-85-348C, and TL-85-348D). At several exposurea in the pit, thrust-faulted and folded graywacke beds within the gravelly diamicton indicate that blocks of the underlying bedrock have been deformed and incorporated into this diamicton. In the west face of the pit, the gravelly diamicton is overlain by a diamicton with a sandy matrix containing 7 to 8 percent clay content (Figure 10; samples SK-85-366A and TL-85-348A). At the southern end of the east face of the pit, a diamicton with a 14 percent clay content (TL-85-348E) was observed. Its relationship with the other diamictons in the pit was not clear in July 1985.

Six fabric analyses have been obtained from this locality (Figure 11). Two fabrics measured in the gravelly diamicton exposed in the west wall suggest that fabric at the bottom of that unit is partly inherited from the east-northeast strike of the underlying bedrock, but a weak northwest-southeast alignment occurs near the top of the unit. The sandy diamicton overlying the gravelly diamicton has a strong north-northwest to south-southeast alignment. The fabric of the gravelly diamicton exposed in the east wall of the pit also is strongly parallel to the orientation of underlying bedrock. The 14-percent-clay diamicton shows an east-southeast to west-northwest fabric. In 1979, an east-southeast to west-northwest fabric also was measured in the old pit, near where the 14-percent-clay diamicton was exposed in 1985. The fact that the 14-percent clay diamicton has a fabric unlike the other diamictons supports the observation that it is a third diamicton unit.

INTERPRETATION

We suggest the gravelly diamicton is deformation till, based on the incorporation and deformation of local bedrock blocks, and the upsection change in fabric from a bedrock-controlled alignment at the base to an ice-flow controlled alignment at the top. The sandy diamicton overlying the gravelly diamicton has a strong north-northwest to south-southeast alignment, possibly produced by northwestward flow associated with the late Wisconsin regional ice cap. The homogeneity and strong fabric of this sandy diamicton suggest it is a basal till. The 14-percent-clay diamicton shows an east-southeast to west-northwest fabric; an orientation parallel to the widespread "eastward" flow, which we interpret as being from the Laurentide Ice Sheet.

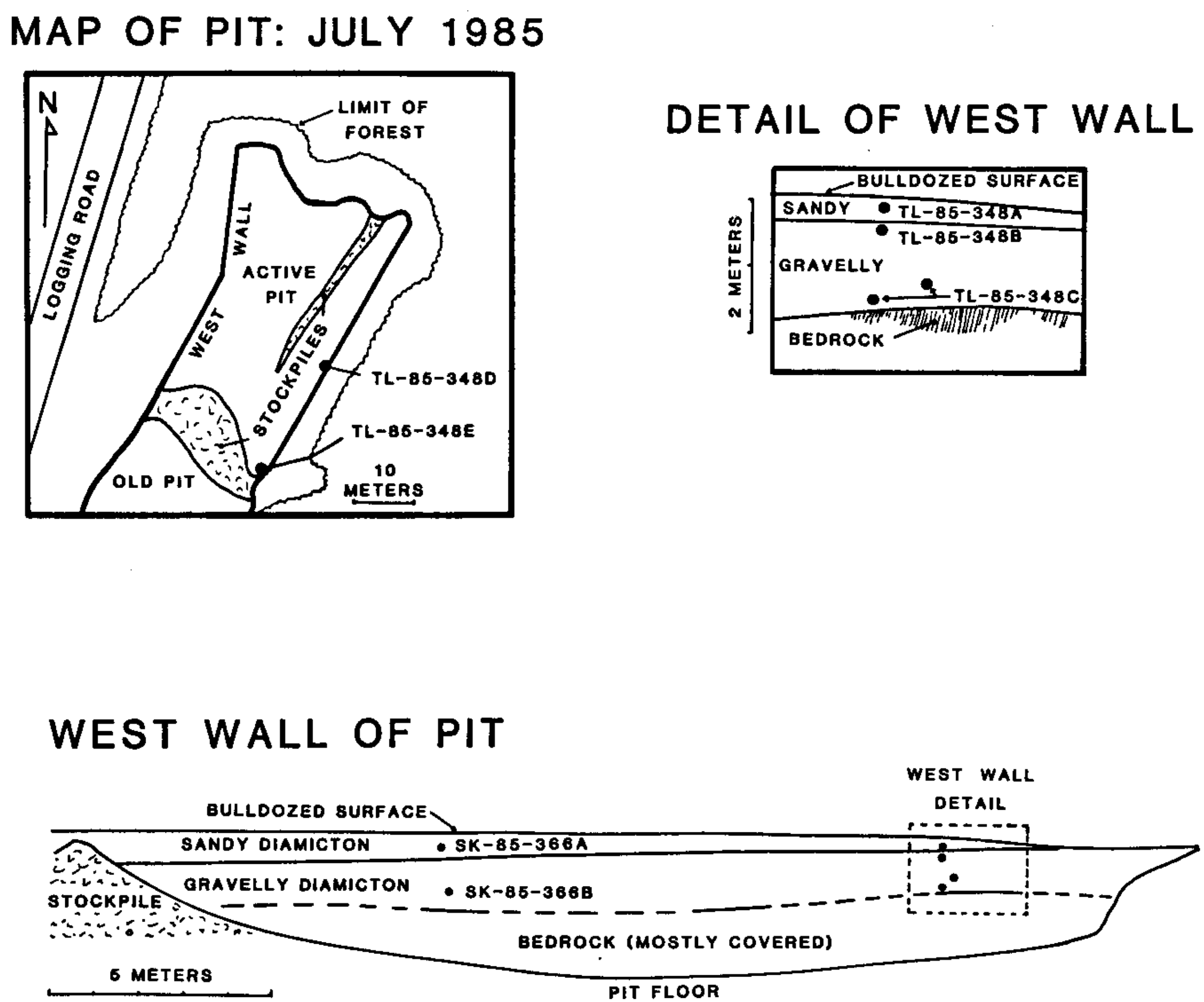


Figure 10. The Rabbit Turn pit. Solid circles denote where samples were taken or where till fabrics were measured (see Table 1 and Figure 11). TL-79-J-4 was taken in the old pit, but that exposure has been destroyed.

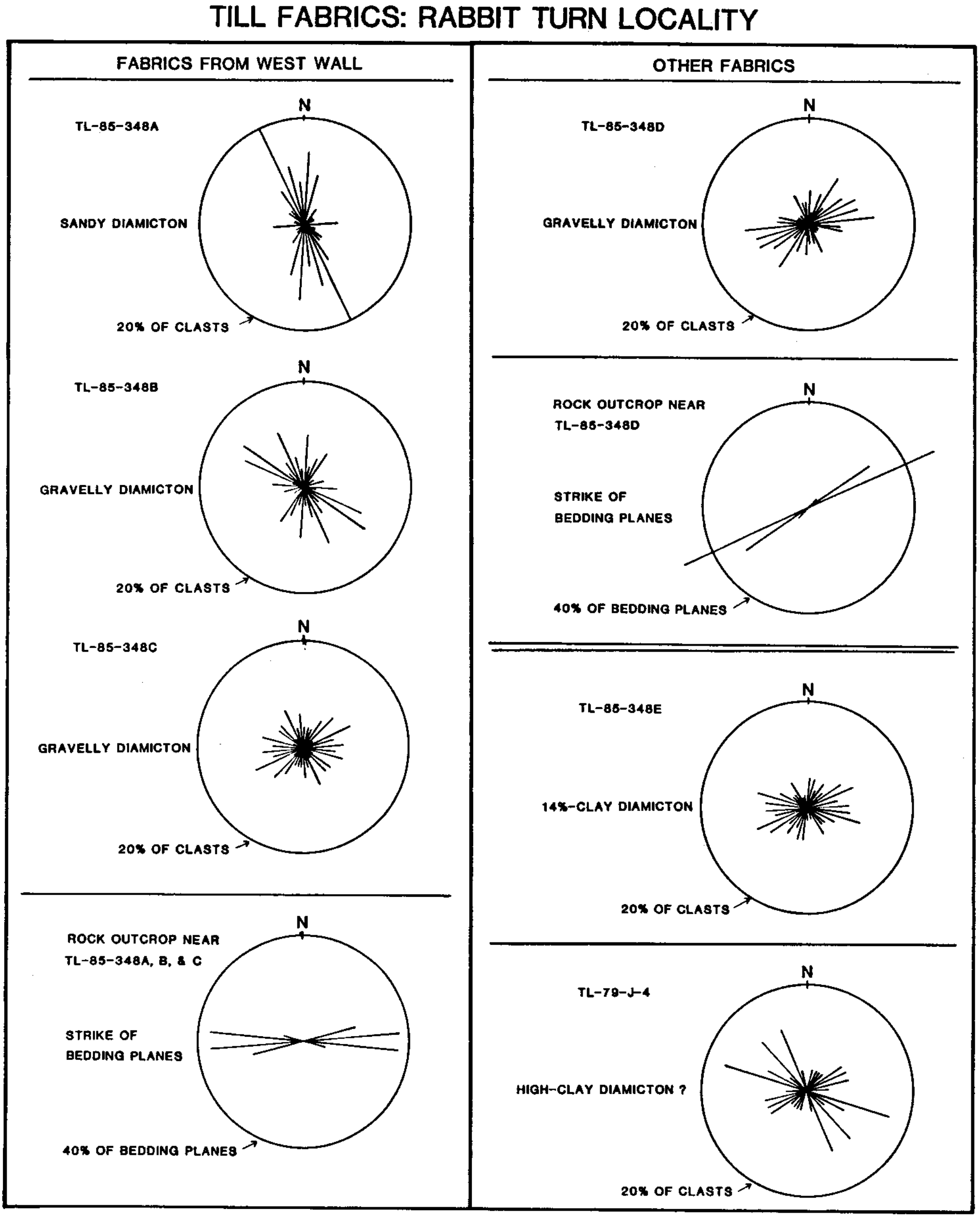


Figure 11. Till-fabric and fracture measurements from the Rabbit Turn pit. Locations are shown on Figure 10.

The 14-percent-clay diamicton may be a basal till that formed during the eastward flow event, but we cannot test this hypothesis without a better understanding of how this unit is related to the other diamictons.

TABLE 1. CHARACTERISTICS OF DIAMICTONS AT THE RABBIT TURN PIT

Sample	unit	height above bedrock (m)	depth from surface (m)	gravel:sand: silt:clay ratio	magnetic suscept. (CGS units X .00001)
		WEST WALL SAMPLES			
TL85-348A	sandy diamict	1.6	>0.2	27:39:27: 7	4.3
TL85-348B	gravelly diamict	1.3	>0.5	87: 9: 3: 1	2.0
TL85-348C	gravelly diamict	0.2-0.4	>1.4-1.6	65:21:11: 3	2.8
SK85-366A	sandy diamict	2.1	>0.2	35:35:22: 8	5.0
SK85-366B	gravelly diamict	0.6	>1.7	61:26:10: 3	2.8
		EAST WALL SAMPLES			
TL85-348D	gravelly diamict	>1.3	2.3	59:30: 8: 3	5.3
TL85-348E	third diamict?	>0.5	2.0	43:20:24:14	2.5

STOP 1-6 DICKEY DELTA (Landform)

DESCRIPTION

A terrace that slopes about 1.5 m/km to the northeast occupies over half of the broad valley at the confluence of the St. John and Little Black Rivers. A few bedrock knolls project up to 8 m above the nearly flat surface (Figure 12). Several river-bluff exposures and one gravel pit show the landform is composed of cobbles, pebbles, and sand. In general, clasts are finer-grained toward the northeast. Many exposures and core logs indicate that fine-grained lacustrine sediments are common in this area; however, we have not seen exposures where the coarse-grained sediments exposed at the top of this landform overlie another unit. Fluvial erosion has incised this landform, as evidenced by the meander scarp near Route 161 at this stop. The unnamed stream draining the northwestern part of the landform and adjacent slopes flows into the Little Black River at an unusually high intersection angle.

INTERPRETATION

Roy and Lowell (1980) interpreted this 2 km-wide landform as a delta. Reinvestigation of the landform confirmed a deltaic interpretation (Nicholas and others, 1981). At least three lines of evidence favor a deltaic origin of the landform; some of this evidence comes from the Little Black River valley, north of the terrace. Firstly, the unnamed stream flowing north along the western end of the landform (Figure 12) has a path that may have been inherited from an old distributary. Secondly, although kame terrace deposits exist at higher elevations in the Little Black River valley, the stratigraphy

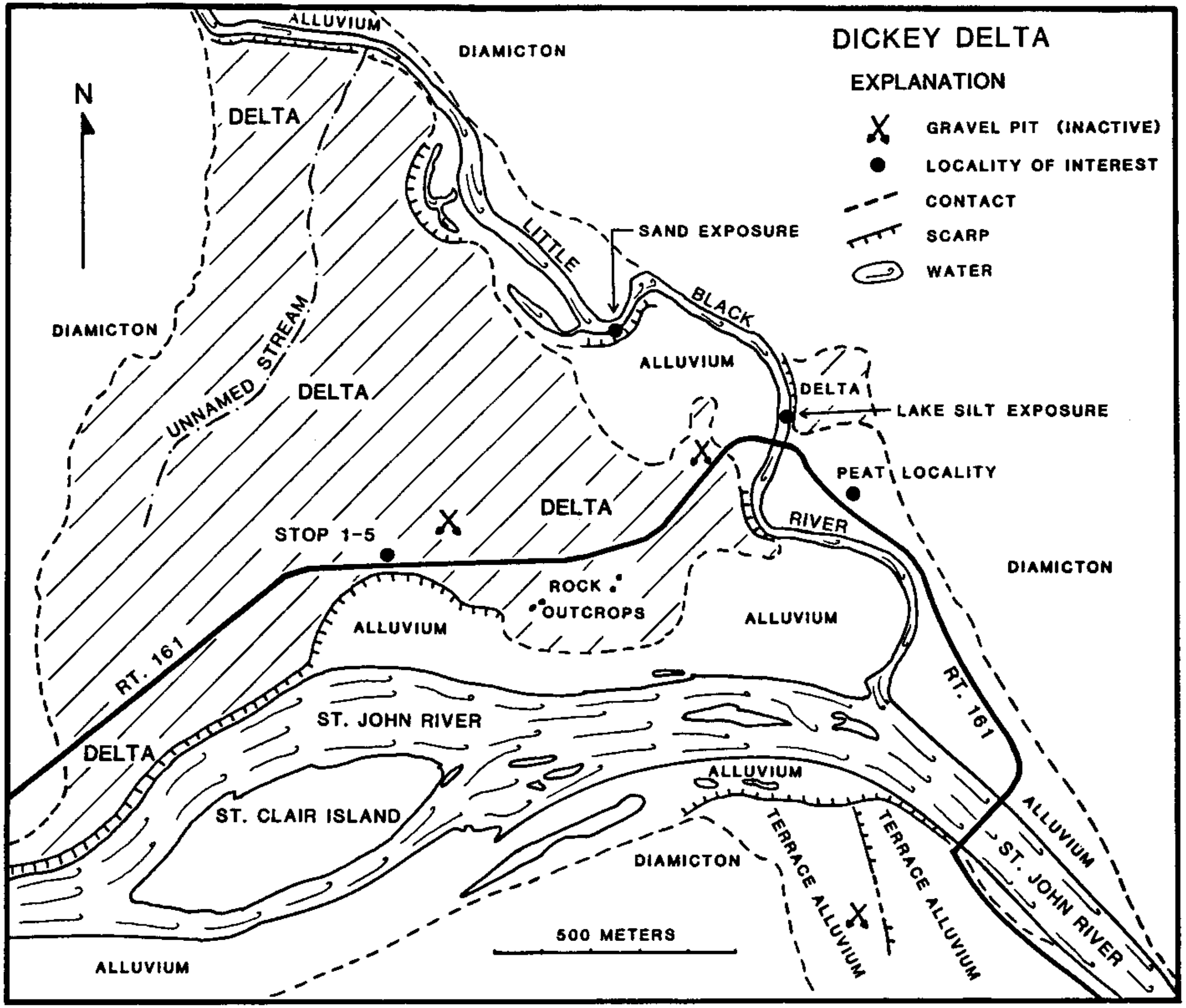


Figure 12. Surficial geology of the Dickey delta area. Delta is shown by cross-hatched pattern.

of that valley bottom shows that lacustrine sediments are conformably overlain by fine-grained postglacial alluvium. This conformable stratigraphy and the eastward fining of terrace sediments suggest that the terrace formed by high-energy flow from the St. John River, while the Little Black valley was occupied by a lake or a chain of lakes connected by low-energy streams.

Finally, the gravel landform is associated with fine-grained lacustrine rhythmites, both further up the Little Black River valley and near the bridge over the Little Black. We cannot demonstrate if the contact between the rhythmites and overlying coarse-grained material is conformable at Dickey. However, a cobble-boulder concentration, interpreted as beach lag, occurs at the upper limit of lacustrine sediments in the Little Black River valley. This cobble-boulder concentration occurs at the same 198 m (650 ft) altitude as the top of the Dickey terrace suggesting both formed on the margins of the same lake. We speculate that the lake was dammed at this altitude by thick cross-valley drift accumulations downstream from the confluence of the Allagash and St. John Rivers.

In summary, we call the broad, flat landform in Dickey a delta because we believe it was graded to a lake plain in the Little Black River valley. Others may prefer to call this feature a fluvial terrace, so we invite the Friends to discuss just what should be called a delta.

For the information of those who may someday continue our investigations in the upper St. John River valley, in 1980, a pond excavation exposed peat overlying lacustrine sediments near the confluence of the Little Black and St. John Rivers (peat locality in Figure 12). Unfortunately, the locality was not sampled before intense rainfall flooded the pond prematurely. Careful coring might yield an important date from the base of the peat or the lacustrine silt.

STOP 1-7 TOILET BOWL OUTCROP (Striated Pavements)

DESRIPTION

Several pavements of Seboomook Formation slate along this stretch of road (Figure 13) show evidence of two directions of ice flow. A few rat-tail striations and grooves indicate that the oldest ice moved toward the east (90-110 degrees). Superimposed on this evidence are striations trending 340/160. The general outcrop shape, position of unstriated faces, and small stoss-and-lee forms indicate that the ice producing this younger set moved toward the northwest (340 degrees). The same relative age relationships between these two sets of erosional features can be seen on 21 other outcrops throughout northwestern Maine.

INTERPRETATION

We suggest that the eastward movement represents influx of ice across the region from a Laurentide source. Later, the ice movement reversed to the northwest in response to downdraw in the St. Lawrence River.

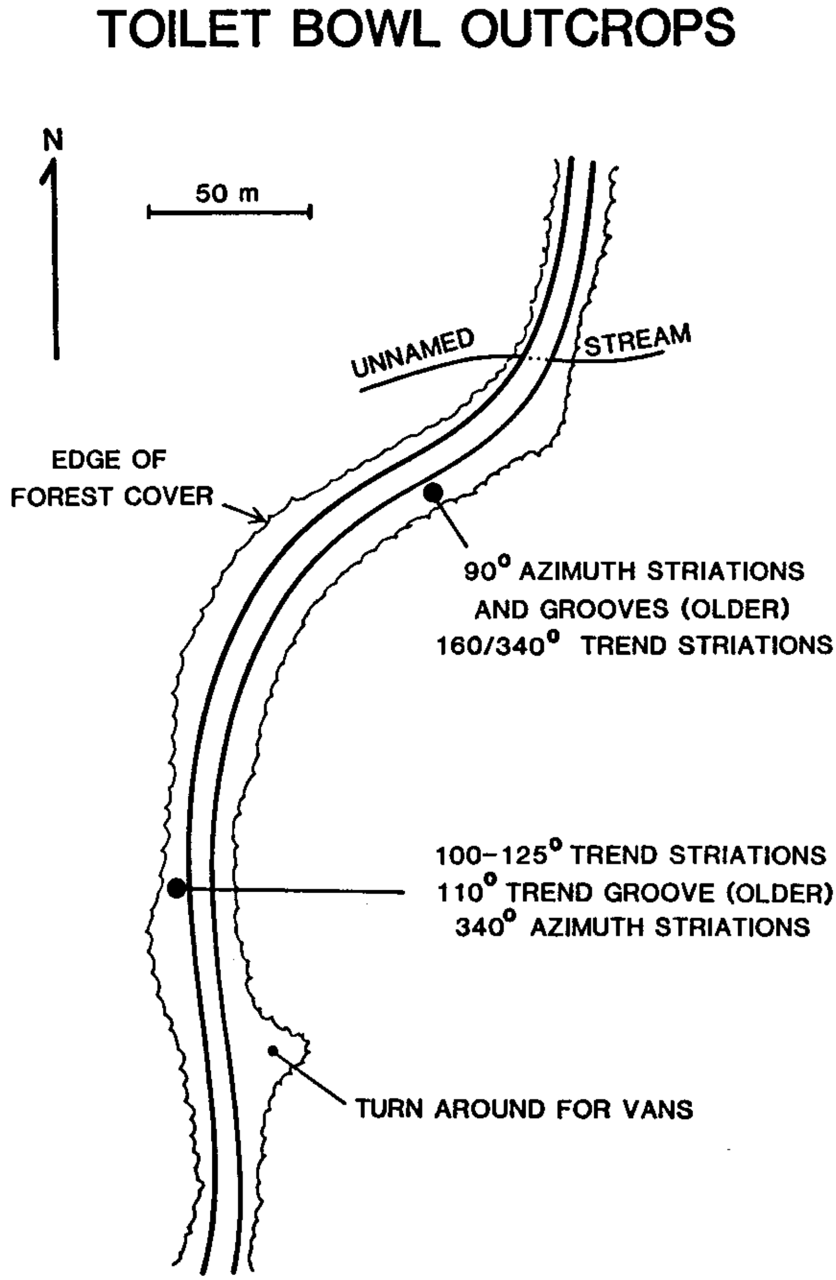


Figure 13. Map of the Toilet Bowl outcrops. The actual toilet bowl was first discovered at the turn-around in 1980. By 1985, it had been reduced to toilet-bowl fragments.

In northern Maine we see no evidence, such as differential weathering or oxidation of striations, to indicate subaerial exposure between these two different ice flows. The simplest correlation of erosional events to the events recorded in the stratigraphy is that the erosion by the eastward ice was associated with deposition of a widespread silty sandy till with strong eastward fabric (i.e. unit 2 at McLean Brook or Golden Rapids). Later, northward-flowing ice eroded portions of the bedrock and left patches of the sandy silty till (i.e. unit 3 at McLean Brook and Golden Rapids). Because we have yet to find any evidence of subaerial conditions in either the erosional or depositional record, we suggest that the northward flow followed the eastward flow without an intervening deglaciation.

STOP 1-8 FORT KENT BLOCKHOUSE (Summary and Discussion)

This stop will be an opportunity to tie together the ideas and information introduced during the first seven stops, in addition to the data and interpretations discussed in the papers in the bulletin that accompanies this field guide. Although we hope that discussion will lead to spirited debate over the items of greatest interest to the Friends, we will start with a review of regional ice-flow history followed by discussion of the style and pattern of deglaciation. Some of the major points we wish to emphasize are as follows:

ICE-FLOW HISTORY

1. The first widely documented ice flow in northwestern Maine was east-southeastward. The orientation and distribution of east-southeastward flow indicators in the region suggest the source was the Laurentide Park area, north of Quebec City.

2. Throughout at least 7000 square km of northern Maine, later ice flow was to the north or northwest, generally a 120 to 150 degree reversal of flow. The flow reversal in Maine was time transgressive, starting first in the northwestern tip of the state, then migrating toward the southeast.

3. The limited northward or northwestward transport of erratics indicates that the flow reversal was short lived relative to the earlier east-southeastward flow.

4. Ice flow ceased and widespread stagnation followed the flow reversal, with the exception of a local north-northeastward flow near the St. John-Chaudiere drainage divide.

5. Field data in northern Maine strongly support downdraw into an ice stream in the St. Lawrence Lowland as a major component of deglaciation.

DEGLACIATION

1. The ice-flow history, especially the late flow reversal, dictated the style of local deglaciation.

2. Meltwater in the northernmost portions of Maine drained to the north and northwest.

3. One poorly developed belt of moraines and ice-marginal deposits may represent a still-stand during deglaciation. These may correlate to similar deposits in adjacent Quebec.

4. The general deglaciation style appears to have been simultaneous stagnation over a wide area. The last isolated blocks of ice dissipated under topographic control.

TRAVEL DIRECTIONS FOR DAY 2

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
0.0	0.0	Crocker Hall, University of Maine at Fort Kent. Assemble at 7:30 A.M. Proceed to Rt. 11.
0.35	0.35	Turn right (north) on Rt. 11.
0.55	0.2	Turn left (west) at triangle.
0.6	0.05	Turn left (west) on Rt. 1. Proceed through downtown Fort Kent.
1.0	0.4	End of U.S. Rt. 1. Proceed straight (west) on Rt. 161. Do not cross bridge to Clair, N. B.
2.25	1.25	Note road to left.
2.3	0.05	Turn right (north) into trailer park. Continue to end of road.
2.5	0.2	Disembark vans and walk approximately 110 meters east. Climb down river bank to outcrop.
	STOP 2-1: ETSCOVITZ LOCALITY (Stratigraphy)	
		Turn vans around. Return to Rt. 161.
2.7	0.2	Turn left (east) onto Rt. 161.
4.0	1.3	Rt. 161 turns into Rt. 1. Continue east on Rt. 1. Cross Fish River at intersection of Rt. 1 and Rt. 11.
4.4	0.4	Turn right (south) onto Rt. 161.
5.65	1.25	Turn left (east) on North Perley Brook Road. Proceed east on outwash terrace.
6.5	0.85	Note gravel pit (site of stop 2-2) on south (right) side of valley. Road riaes up to right onto higher terrace.
7.1	0.6	Turn right (south) on unnamed gravel road.

TOTAL MILEAGE	INTERVAL MILEAGE	DIRECTIONS OR POINTS OF INTEREST
7.4	0.3	Cross Perley Brook.
7.5	0.1	Turn right (west) on South Perley Brook Road.
8.15	0.65	Turn right into Nadeau gravel pit.
8.30	0.15	Stop in pit.
	STOP 2-2: PERLEY BROOK LOCALITY (Gravel Pit)	
		Return to South Perley Brook Road.
8.45	0.15	Turn right on South Perley Brook Road.
8.8	0.35	Road "drops off" of high outwash terrace.
9.2	0.4	Cross railroad tracks.
9.25	0.05	Turn left (south) on Rt. 161.
9.3	0.05	Turn right (west). Cross Fish River.
9.5	0.2	Turn right (north) on Rt. 11.
10.35	0.85	Turn right at University of Maine at Fork Kent.
10.6	0.25	Crocker Hall parking lot.
	END OF TRIP	

DESCRIPTIONS OF STOPS FOR DAY 2

STOP 2-1: ETSCOVITZ LOCALITY (Stratigraphy)

DESCRIPTION

Two different stratigraphic sequences have been exposed at this locality (Figure 14). During 1981 and 1982, vegetation covered the upper 3 m of the sequence at this locality, but soils in the adjacent field indicated a surface gravelly sandy loam unit. The uppermost exposed unit was 2 m of gray, silty diamicton. Pebble-fabric analysis of the diamicton showed an east-west clast alignment (Figure 15). At least 6.5 m of gray, rhythmically bedded silt were exposed below the silty diamicton. The silt was differentiated into an upper, relatively well-bedded, 4 m-thick silt unit, and a lower, poorly bedded, clayey-silt unit. The top 40 cm of the upper silt unit was oxidized. A meager diatom assemblage found in a sample from the bottom of the upper silt unit indicates deposition in a lake with extremely low biological activity, and a possible year-round ice cover (Davida Kellogg, written correspondence, 1983; see Kite, 1983, p. 295 for species list).

The exposure studied in 1981-1982 was not well exposed in 1985; however, a nearby slope failure revealed a more complex stratigraphy (Figure 14). The surface unit of 3.0 m of weakly bedded sandy diamicton and poorly sorted sand was well exposed. Below the surface unit were 1.0 m of sandy diamicton, 0.9 m of brown (2.5Y 5/2) diamicton, 1.5 m of sandy gravel, 0.5 m of sandy diamicton, 2.4 m of gray (5Y 5/1 to 5Y 5/2), silty diamicton, and, at the bottom of the exposure, 3.3 m of well-deformed silt, clay, and sand rhythmites that could not be differentiated into smaller units. Fabric measurements on 25 clasts from two of the diamictons exposed in 1985 show a northeastward alignment, unlike the fabric measured in 1982 (Figure 15).

INTERPETATION AND CORRELATION

The Etscovitz locality presents many problems as to correlation and origin of the sequence. As in the case of the Golden Rapids locality, it is not perfectly clear how to correlate from one exposure at the locality to the other, much less how to correlate the locality to other localities in the region. We believe we have answers to some of these problems; we hope the Friends can help us find the answers to others.

Interpretaton of the units overlying the gray, silty diamicton is problematic. All of the 5 upper units exposed in 1985 can be interpreted as products of meltwater or debris flow during deglaciation of the St. John River valley. Alternately, the 1.5 m-thick sandy gravel may represent subaerial deposition during an interstadial followed by another glaciation which deposited a brown diamicton. Although we favor the first hypothesis, we invite the Friends to debate this issue.

Is the gray, silty diamicton exposed in 1985 the same lithostratigraphic unit as the gray, silty diamicton exposed in 1981 and 1982? Their close proximity and similar position in the stratigraphic section suggest they are, but why are their fabrics different? Is either fabric representative of a regional ice-flow event? Assuming there is only one gray, silty diamicton unit

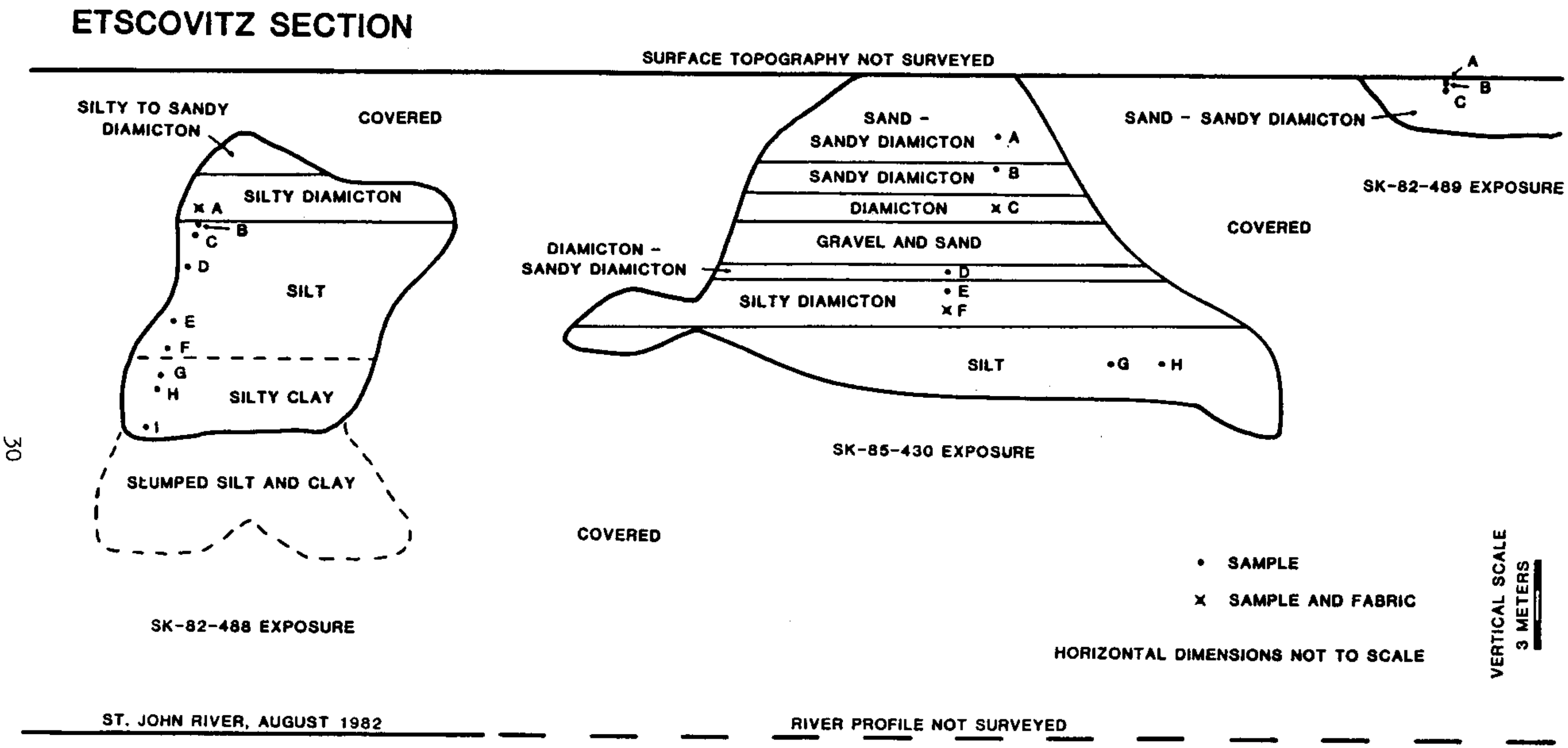


Figure 14. The Etscovitz section, based on visits in 1982 and 1985. More complete descriptions and measured unit thicknesses are given in the text. Till fabrics are shown in Figure 15.

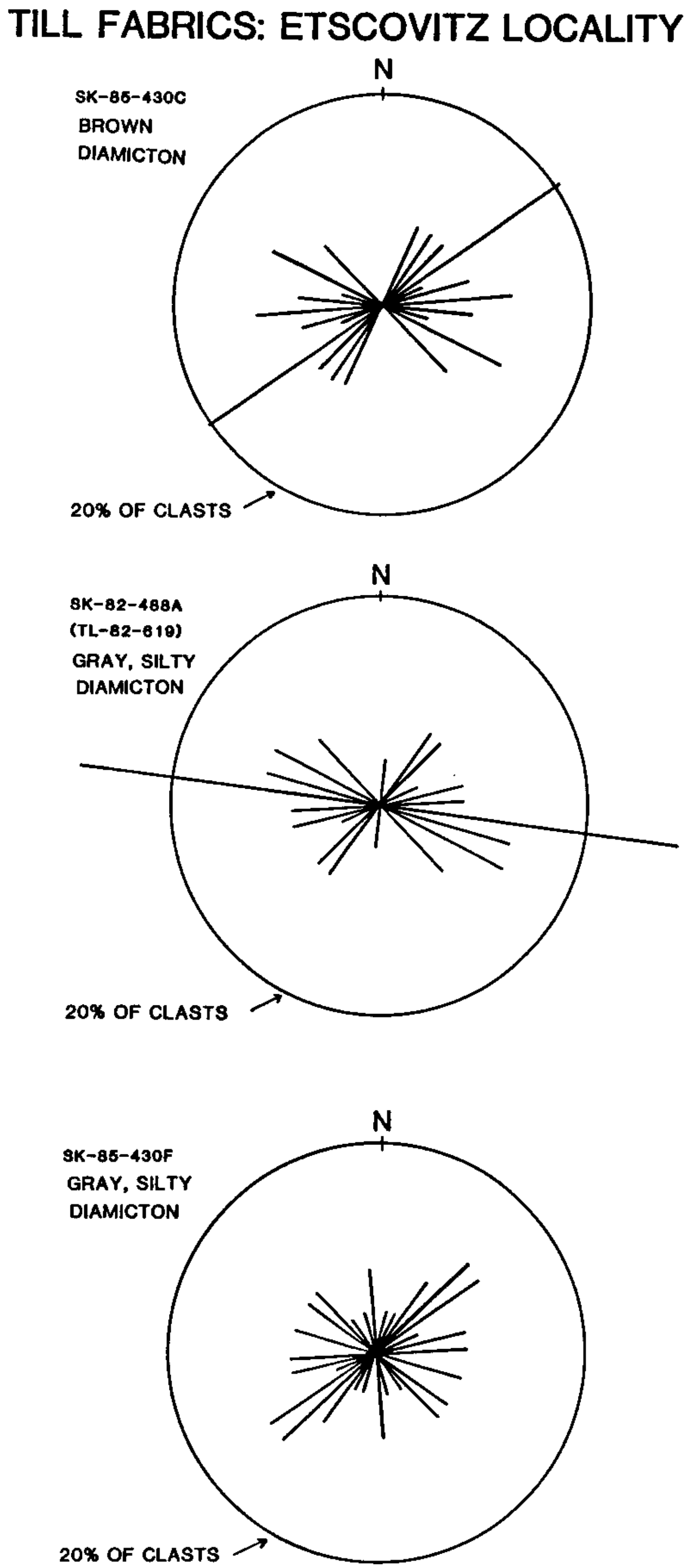


Figure 15. Till fabrics measured at the Etscovitz locality.

at the Etscovitz locality, is it equivalent to the gray diamictons exposed in the McLean Brook and Golden Rapids localities (Stops 1-3 and 1-4)? The materials are similar in color, texture, and appearance, but the 1985 fabric analysis in the gray, silty diamicton at the Etscovitz locality does not indicate deposition by the same strong eastward flow. The difference in fabric may represent only local variation in flow, so a tentative correlation is suggested, pending additional stratigraphic studies in the Fort Kent area.

Finally, how should the silt units be interpreted? They appear to record lacustrine deposition before or during advance of the glacier that produced the gray, silty diamicton (the late Wisconsin Laurentide Ice Sheet?). If gray, silty diamicton at the Etscovitz locality is the same lithostratigraphic unit as seen at the McLean Brook and Golden Rapids sections, then lacustrine deposition in the Fort Kent area may have been contemporaneous with deposition of sand and gravel further up valley.

ONLY THE TOP OF THE SECTION

The Etscovitz locality represents only the top of the complex Quaternary stratigraphy in the Fort Kent area. Prescott (1971; 1973) reports several wells drilled 5 to 6 km northeast of this site, in which till overlies glacial-lake deposits. Another well, 1.0 km west of this locality, yielded a piece of wood that gave a radiocarbon date of >38,000 B.P. (W-2572; Prescott, 1973). The old wood came from a diamicton 44 m below the surface, probably a unit stratigraphically lower than any of the deposits exposed at the Etscovitz locality. Prescott (1973) suggested that high water yields from this well at 65 m depth indicated that a coarse fluvial unit lies below the wood-bearing diamicton.

A complex stratigraphy has been observed elsewhere in the St. John River valley. At least three diamictons interbedded with fluvial and lacustrine deposits occur in a 70 m-thick sequence near Allagash, 40 km west of the Etscovitz locality (Prescott, 1971; 1973; Lowell and others, in press) Although there may be fewer subsurface diamicton units in the St. John River valley east of Fort Kent, every Quaternary geologist working in northeastern Maine and adjacent New Brunswick has identified some sort of diamicton overlying some other type of sediment. Indeed, it is the stratigraphic complexity and variability from exposure to exposure that has prompted so much debate in the past, and will continue to spur controversy in the future.

STOP 2-2: PERLEY BROOK (Gravel Pit)

DESCRIPTION

Sediments and landforms along Perley Brook indicate that meltwater drained to the north and northwest. Genes (1981) mapped outwash deposits in the northwestern portion of the valley. Additional mapping in 1985 showed that well-stratified sediments are restricted to the lowest surfaces in the valley (Figure 16). These stratified sediments are adjacent to higher, poorly bedded ice-contact gravels, sands, and diamictons. Terraces and well-sorted sediments are restricted to the valley adjacent to the South Branch of Perley Brook. One might debate whether these sediments should be called outwash or ice-contact stratified drift.

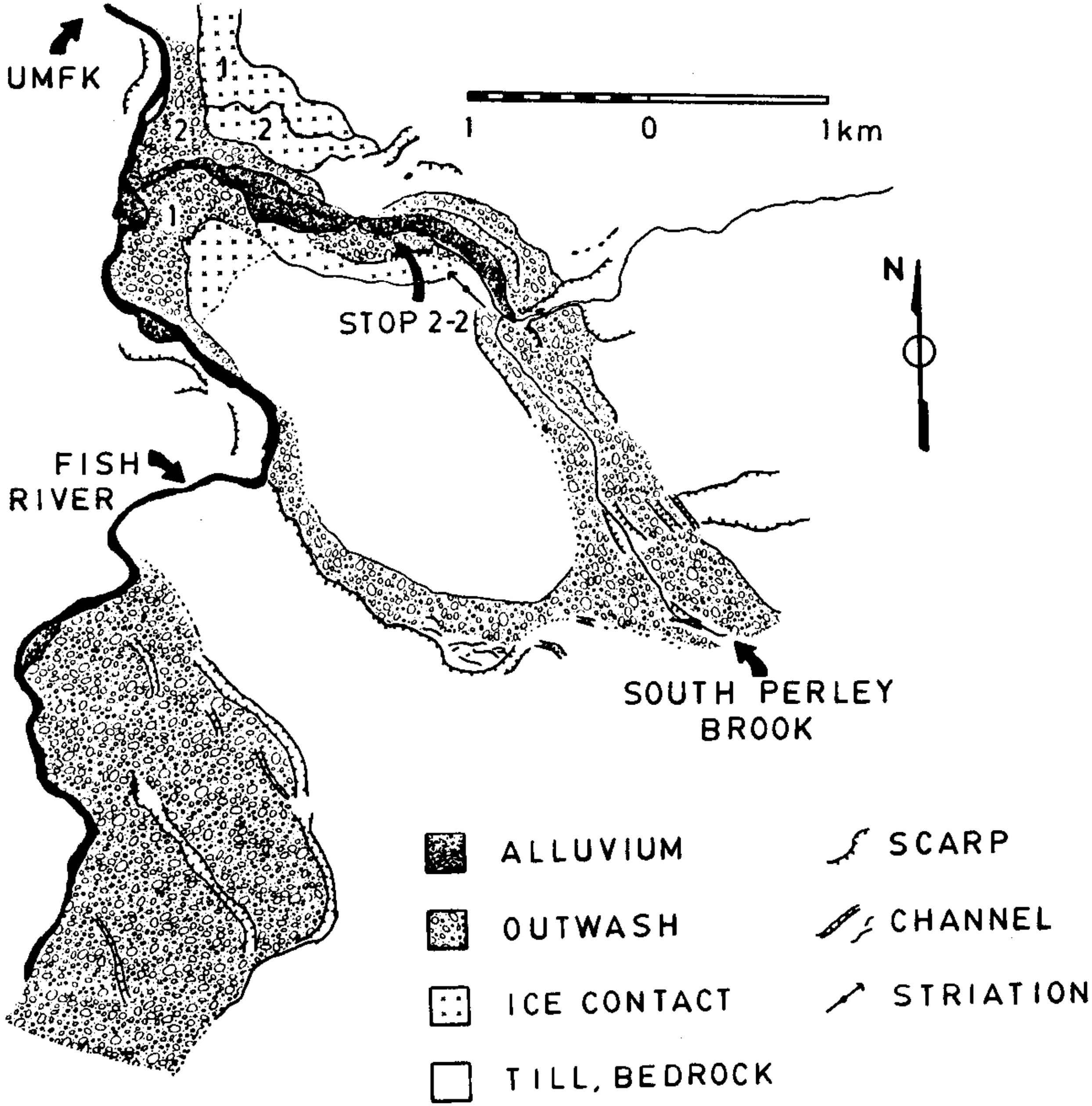


Figure 16. Simplified surficial geology near Perley Brook, Fort Kent (Stop 2-2). The relative age of similar units indicated with numbers, 1 being the oldest.

INTERPRETATION

In either case, probably the most important point of this stop is that the sediments and landforms show that ice-dammed lakes did not develop in this northwestward-draining watershed during the last stages of deglaciation. Like Perley Brook, meltwaters in most other north-draining or west-draining tributaries in the area show drainage from a meltwater source to the southeast toward open drainage to the northwest. This general pattern is consistent with ice recession from northwest to southeast.

REFERENCES CITED

Becker, D.A., 1982, Late Wisconsin stratigraphy, upper St. John River, northwestern Maine: M.S. thesis, State University of New York, Buffalo, 95 p.

Becker, D.A., Lowell, T.V., and Calkin, P.E., 1982, Late Wisconsin stratigraphy, upper St. John River, northwestern Maine: Geological Society of America, Abstracts with Programs, v. 14, p. 4.

Brewer, T., Genes, A.N., and Newman, W.A., 1983, The evidence for pre-late Wisconsinan till in the St. John River valley, Northern Me.: Geological Society of America, Abstracts with Programs, v. 15, p.124

Genes, A.N., 1981, Surficial geology of the Eagle Lake, Maine quadrangle: Maine Geological Survey, Open-File Map 81-12.

Genes, A.N., and Newman, W.A., 1980, Wisconsinan glaciation of northern Aroostook County, in Roy, D.C., and Naylor, R.S., eds., New England Intercollegiate Geological Conference Guidebook for Field Trips in Northeastern Maine and Neighboring New Brunswick, p. 179-188.

Genes, A.N., and Newman, W.A., 1983, Letters to the editor: reply to comment on "Late Wisconsinan glaciation models of northern Maine and adjacent Canada": Quaternary Research, v. 19, p. 272-274.

Genes, A.N., Newman, W.A., and Brewer, T., Late Wisconsinan glaciation models of northern Maine and adjacent Canada: Quaternary Research, v. 16, p. 48-65.

Halter, E.F., 1985, Glacial dispersion from two plutons, northern Maine: M.S. thesis, State University of New York, Buffalo, 135 p.

Kite, J.S., 1979, Postglacial geologic history of the middle St. John River valley: M.S. thesis, University of Maine, Orono, 136 p.

Kite, J.S., 1983, Late Quaternary glacial, lacustrine and alluvial geology of the upper St. John River basin, northern Maine and adjacent Canada: Ph.D. dissertation, University of Wisconsin, Madison, 339 p.

Kite, J.S., Lowell, T.V., and Nicholas, G.P., 1982, Quaternary studies in the St. John River Basin: Maine and New Brunswick: in Thibault, J., ed., Guidebook for the 1982 NBQUA field trip, 54 p.

Lowell, T.V., 1980, Late Wisconsin ice extent in Maine: evidence from Mount Desert Island and the Saint John River area: M.S. thesis, University of Maine, Orono, 180 p.

Lowell, T.V., 1986, Late Wisconsin stratigraphy, glacial ice flow, and deglaciation style: northwestern Maine: Ph.D. dissertation, State University of New York, Buffalo.

Lowell, T.V., Becker, D.A., and Calkin, P.E., in press, Quaternary stratigraphy in northwestern Maine: a progress report: Geographie physique et Quaternaire.

Lowell, T.V., and Kite, J.S., 1986, Glaciation style of northwestern Maine: in Kite, J.S, and others, eds., Contributions to the Quaternary Geology of Northern Maine and Adjacent Canada: Maine Geological Survey, Bulletin 37, 141 p.

Lowell, T.V., Kite, J.S., Becker, D.A., and Borns, H.W., Jr., 1983, Comment on: "Late Wisconsinan glaciation models of northern Maine and adjacent Canada": Quaternary Research, v. 19, p. 136-137.

Maher, K.P., 1981, Determination of the mechanism responsible for the color difference in the glacial till of the St. Francis Formation, Golden Rapids, Allagash, Maine: senior thesis, Boston College, Boston, 35 p.

Nicholas, G.P., II, Kite, J.S., and Bonnichsen, R., 1981, Archaeological survey and testing of late Pleistocene-Early Holocene landforms in the Dickey-Lincoln School reservoir area, northern Maine: Orono, Maine, Institute for Quaternary Studies report, 170 p.

Prescott, G.C., Jr., 1971, Lower St. John River area: record of selected wells, springs and test holes in the lower St. John River Valley: U.S. Geological Survey, Maine Basic Data Report no. 6, Ground-water Series, 22 p.

Prescott, G.C., Jr., 1973, Groundwater favorability and surficial geology of the lower St. John River valley, Maine: U.S. Geological Survey, Atlas HA-485.

Roy, D.C., 1980, Evaluation of the mineral potential, upper St. John River valley, Aroostook County, Maine -- Appendix A: Bedrock geology of pre-Devonian rocks in northwestern-most Aroostook County, Maine: Maine Geological Survey, Open-File Report 80-14b, 34p.

Roy, D.C., and Lowell, T.V., 1980, Bedrock and surficial geology of the Upper St. John river area, northwestern Aroostook County, Maine: The Geological Society of Maine, Guidebook for Field Trip 5, 14 p.