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# THE SEBOOMOOK LAKE AREA BECAME ICE FREE; BUT HOW ?

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## INTRODUCTION

During the summer of 1983 we conducted surficial mapping and investigations in the Seboomook Lake area and along the West Branch of the Penobscot River. Reconnaissance checks and examination of prior work (Brewer and Caldwell, 1975) led us to hypothesize the existence of very large post- or proglacial lakes that spread from Moosehead Lake to Chesuncook Lake (Fig. 1). Low drainage divides now connect the two basins. The area is also interesting because at least 3 major river basins drain from it; the St. John River to the north, the West Branch of the Penobscot to the east and the Kennebec to the south. Additionally the headwaters of the Allagash Basin is only 50 km to the northeast. However one must drop 40 m from Seboomook Lake to that drainage. The extremely low topography provides numerous spillways for drift or ice-dammed lakes.

The region could possess complex deglaciation patterns because it lies just south of regions Kite and Lowell (1982) suggested as the site of the last remnant of a receding ice mass. Lowell (in press) documented the southward retreat of ice from the Maine-Quebec border. This contrasts with numerous works describing the northward recession of the same ice mass (e.g. Caldwell, 1975; Newman, 1982). Because the Seboomook region lies at the north end of previously mapped areas and just south of the ice divide, insight to the deglaciation of a small ice mass may lie waiting in the deep woods.

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The prior surficial mapping in the area is limited, neither Stone (1899) or Leavitt and Perkins (1935) got this far north. However, Caldwell (1975) first suggested that the Lobster basin (Fig. 1) contained a glacial lake dammed near Smith Halfway House on the West Branch of the Penobscot. He postulated two lake levels, the first at 1040 and the second at 1020+ feet, both draining into the Moosehead Lake basin. Glacial retreat to the north provided gravel deposits that covered the lake sediments.

The bedrock in the Seboomook area includes rocks of Lower Devonian to Ordovician or Silurian age. The map units (Marvinney, 1983) include the Seboomook Formation of cyclically bedded gray slate and fine sandstone; the Ironbound Mountain Slate of gray slate with minor greenish-gray phyllite; Frontenac Formation of interbedded gray to bluish-gray fine sandstone and wackie and thinly bedded dark slate; and the Canada Falls Volcanic Member of dark green basalt and minor intercalated dark green slate. Minor intrusive rocks include metadiabase and felsic dikes. The regional bedrock structure suggest these units continue northeast into the St John Pond and Northeast Carry quadrangles. However, Pollock (unpub.) mapping in quadrangles to the north, reports a somewhat different stratigraphy. In addition to the Frontenac and Seboomook Formations, Pollock includes green slate, basalt lava flows of low metamorphic grade, volcanic breccias and ashes, and sandstone and dark slate.

Given this setting we set out to map the distribution of lake sediments and deltas, measure the elevations of deltas, beaches and spillways, describe related sand and gravel deposits, and map other surficial features. Of course life is not that simple and what we found does not resemble the gravel deposits of southern New England. The drift sequence, although displaying all of the classic glacial features is quite thin.

On this trip we would like to focus on the deglaciation in the Seboomook Lake area. In this context three secondary themes fall out; 1) ice-flow history (one must consider of the interplay of Laurentide versus local ice); 2) deglaciation style of an ice mass of limited extent; and 3) postglacial lake development. Naturally we can not see the local evidence in any semblance of order, so we ask the reader to bear with us and shift his or her viewpoint back and forth from ice cap to gravel pit. Your input will aid preparation of the final report.

We wish to thank the following for assistance, both in the field and with data reduction; Rob Pockaly, Bill Naughton, Linda Healy, and Chris Viani. Discussions with W. Holland, W. Thompson and P. Calkin helped evolve our ideas. The generosity of Walter Anderson and the Maine Geological Survey provided the money and support to get into this mess in the first place.

## ICE-FLOW HISTORY

In order to study the glacial events prior to deglaciation it is necessary to understand the ice-flow history. This information is extracted from striations etched onto bedrock surfaces. In the present study area approximately 250 observed locations show evidence of former ice-flow. Over 100 of these display multiple striations that demonstrate changes in glacier flow directions.

On an outcrop basis it is necessary to separate scratches which have associated azimuth criteria, such as stoss-and-lee forms or rat-tails, versus those which only show trends. This discrimination leaves 56 % of the outcrops with directional criteria. Because all azimuth locations show flow toward the E or SE quadrants, it is assumed that the trend localities also flow in the same direction. This assumption is made to allow a larger data base for relative age determinations. Care should be excised because regions to the north show a more complex history of flow reversals (Lowell, 1980).

When plotted on a Rose diagram (Fig. 2) 3 primary directions break out; E-ESE (50°-110°), SE (145°), SSE (>155°). These groups may seem somewhat arbitrary but are based on age relationships, map distribution, and relative erosional strengths.

Isolating only those multi-direction locations allows changes of ice-flow to be deduced. The relative ages are based on outcrop observations that younger striations can be traced up to, into, and across the floor of the older striations and grooves cut by prior ice-flow. Using the 3 different flow directions allows the following shifts to be noted:

1) from E-ESE to SE (31 locations)
2) from SE to SSE ( 8 locations)
3) from SE to E (29 locations)

This leads to the following ice-flow history. First ice flowed to the E-ESE with a major subsequent shift to the SE. The SE is the dominate flow which has a reduced shift to the SSE over-printed on it. The final flow is again to the E-ESE. The two flows to the E-ESE are separated by the stratigraphic position of the SE flow. The dominate SE indicators lie both above and below eastward flow indicators. A second possible explanation of the observed field data requires a single eastward flow with two SE flows, one below and one above. However, the first sequence draws support from the observation that those E indicators lying below the SE are oriented uniformly toward 115, are widespread, and are always grooves or large striations. In contrast the E indicators lying above the SE are variable with directions from 50 to 125°, are limited in distribution to west facing slopes, and are always faint etchings. At 3 locations the entire sequence of E to SE and back to E are present. The last eastward ice-flow has some strength because flow indicators are well displayed at high elevations on Little Russell Mt. in the St. John Pond quadrangle.

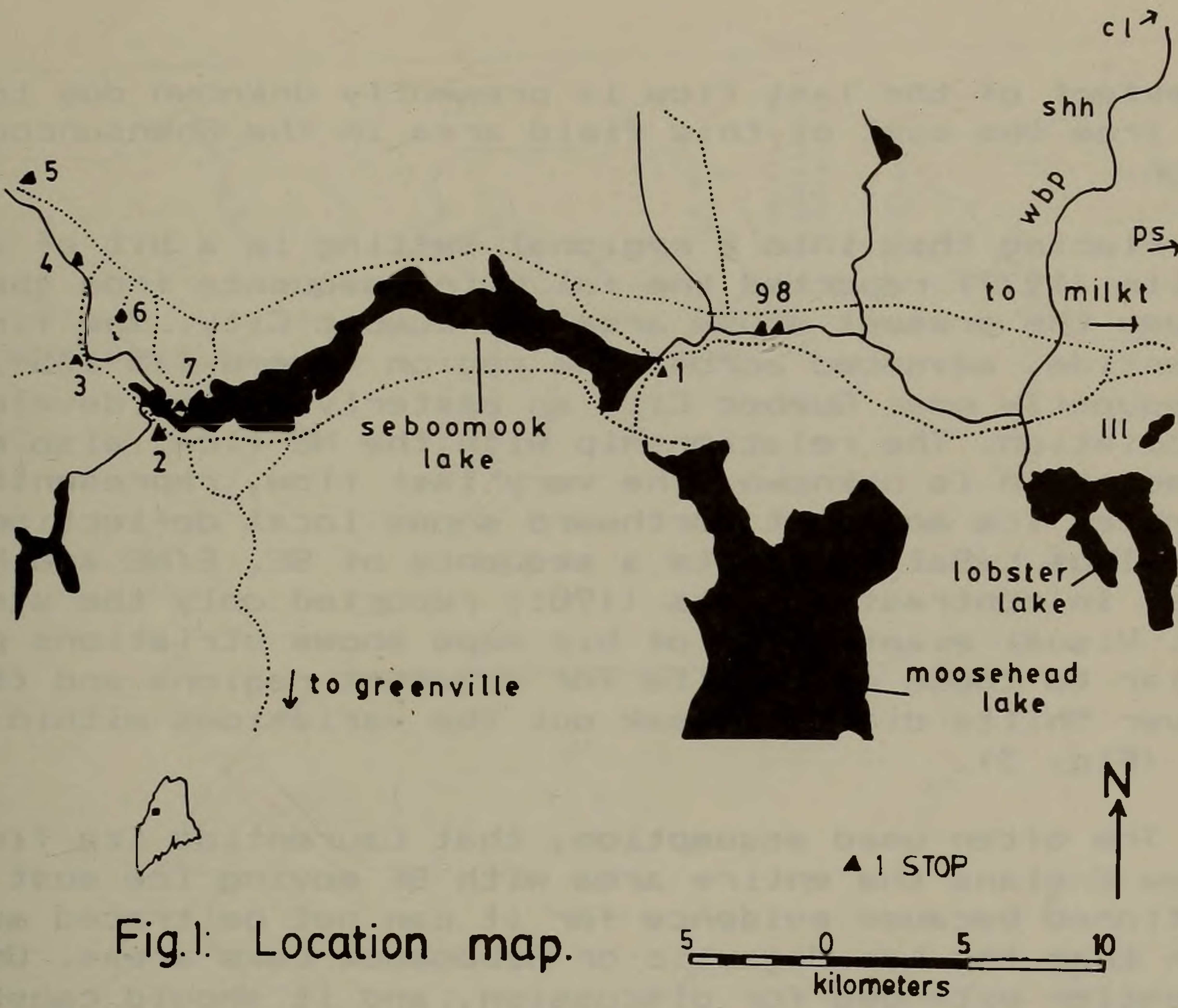


Figure 1. Location map of the Seboomook Lake area. Stops shown as triangles. cl = Chesuncook Lake, shh = Smith Halfway House, ps = Pine Stream, lll = Little Lobster Lake, wbp = West Branch of the Penobscot River.

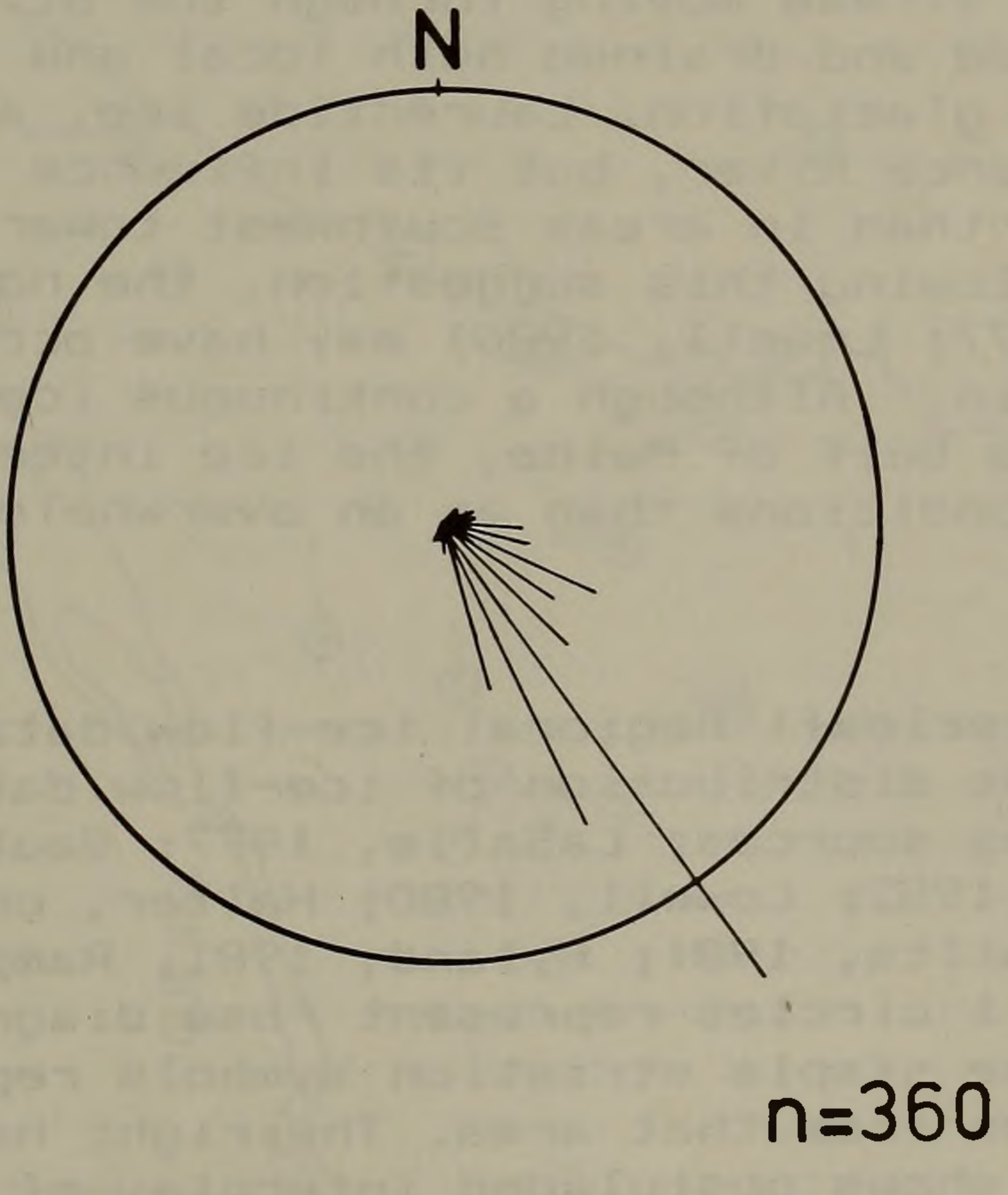


Figure 2. Rose diagram of striation locatilies. Circle at 25 %.

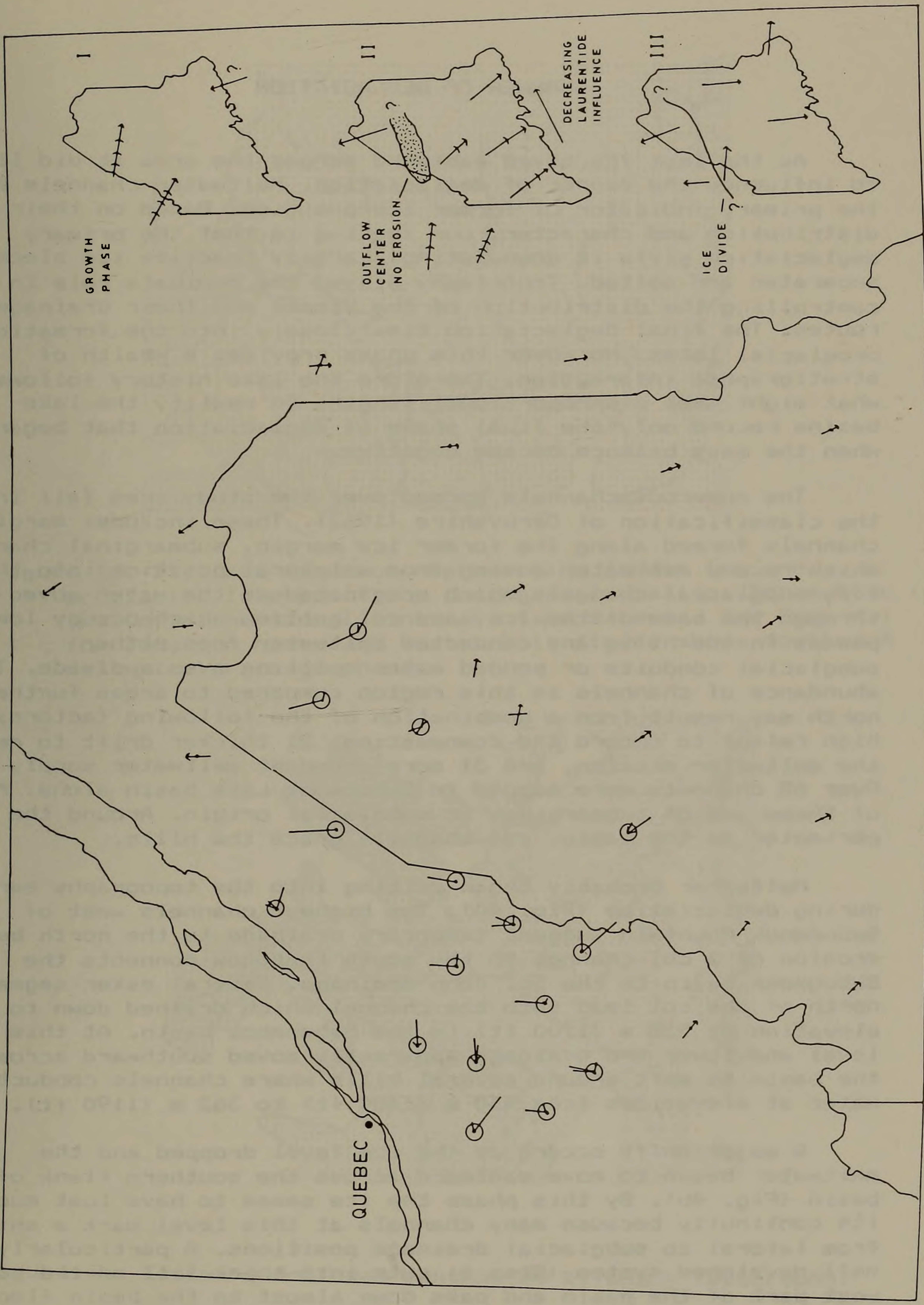
The extent of the last flow is presently unknown due to limited data from the east of this field area in the Chensuncook Lake region.

Placing this into a regional setting is a bit of a trick. LaSalle (1977) reported the following sequence from the region between the present study area and Quebec City. The first ice, Laurentide, advanced across the region toward 115-135°. Subsequently near Quebec City an easterly system developed during deglaciation. The relationship with the NE flow, also related to deglaciation is unknown. The very last flow, representing separated ice movement northward shows local deflections in its flow. Thus LaSalle reports a sequence of SE, E/NE and N ice-flows. In contrast, Shilts (1981) reported only the strong SE flow. Visual examination of his maps shows striations patterns similar to those of LaSalle for adjacent regions and this report, however Shilts did not break out the variations within the SE flow (Fig. 3).

The often used assumption, that Laurentide ice flooded all of New England the entire area with SE moving ice must be questioned because evidence for it can not be traced much further north than the Lac Megantic or Seboomook Lake areas. One suggestion extended for discussion, and it should cause some, is that the widespread SE flow results from an influx of Laurentide ice combined with outflow from northern Maine. As one moves from southwestern Maine along the coast toward the northeast the effects of Laurentide ice decrease and the effects of local ice increase (Fig. 3).

The ice stream moving through the St. Lawrence lowland may have persisted and drained both local and Laurentide ice through out the last glaciation. Laurentide ice, at times, could cross the St. Lawrence River, but its influence in northern Maine would be much less than in areas southwest toward New Hampshire and Vermont. Following this suggestion, the northward flowing ice (LaSalle, 1977; Lowell, 1980) may have occurred for most of the late Wisconsin. Although a continuous ice cover extended from Quebec to the Gulf of Maine, the ice interacted in response to more local conditions than as an overwhelming ice mass.

Figure 3. (overleaf) Regional ice-flow data. The large diagram shows the distribution of ice-flow data compiled from the following sources; LaSalle, 1977; Gauthier, 1980; Kite and others, 1982; Lowell, 1980; Halter, unpublished; Newman, 1980; Shilts, 1981; Hyland, 1981, Rampton and Paradis, 1980. The small circles represent rose diagrams with the circle at 10 %. The simple striation symbols represent visual estimates from that area. The right hand portion of the diagram shows postuladed interplay of Laurentide and local ice during the late Wisconsin. More hatchers on flow arrows indicate more influence of Laurentide ice.



I
GROWTH PHASE
II
OUTFLOW CENTER NO EROSION
DECREASING LAURENTIDE INFLUENCE
III
ICE DIVIDE
?
QUEBEC

## MANNER OF DEGLACIATION

As the last ice moved eastward across the area it did little to influence the manner of deglaciation. Meltwater channels are the primary indicator of former ice position. Based on their distribution and character, our feeling is that the primary deglaciation style is downwasting. Largely inactive ice blocks separated and melted. Topography played the dominate role in controlling the distribution of the blocks and their drainage routes. The final deglaciation ties closely into the formation of proglacial lakes. Moreover this phase provides a wealth of stratigraphic information. Therefore the lake history follows at what might seem disproportional length. In reality the lake basins record only the final phase of deglaciation that began when the mass balance became negative.

The numerous channels spread over the study area fall into the classification of Derbyshire (1962). These include: marginal channels formed along the former ice margin, submarginal channels which record meltwater moving from a lateral position into the ice, subglacial channels which originated as the water moved through the base of the ice, and col gullies which occupy low passes in the hills and conducted meltwater from either subglacial conduits or ponded water spilling over a divide. The abundance of channels in this region compared to areas further north may result from a combination of the following factors; 1) high relief to record the downwasting, 2) thicker drift to record the meltwater erosion, and 3) more abundant meltwater supply. Over 65 channels were mapped in Seboomook Lake basin alone. Most of these are of submarginal or subglacial origin. Around the perimeter of the basin, col channels grace the hills.

Meltwater probably began cutting into the topography early during deglaciation (Fig. 4A). The highest channels west of Seboomook Mountain suggest temporary drainage to the north before erosion of a col channel to the south that now connects the Seboomook basin to the St. John drainage. Several esker segments north of the col lead into the channel which drained down to an elevation of 518 m (1700 ft) in the Seboomook basin. At this level and lower the drainage apparently moved southward across the basin to exit around several hills where channels conducted water at elevations from 430 m (1400 ft) to 362 m (1190 ft).

A major shift occurs as the ice level dropped and the meltwater began to move eastward across the southern flank of the basin (Fig. 4b). By this phase the ice seems to have lost much of its continuity because many channels at this level mark a shift from lateral to subglacial drainage positions. A particularly well developed system (Stop 6) cuts into thick till on the north west part of the basin and pass down almost to the basin floor. The presence of several chutes at the 365 m (1200 ft) level may reflect a relatively long stand of ice at that position.

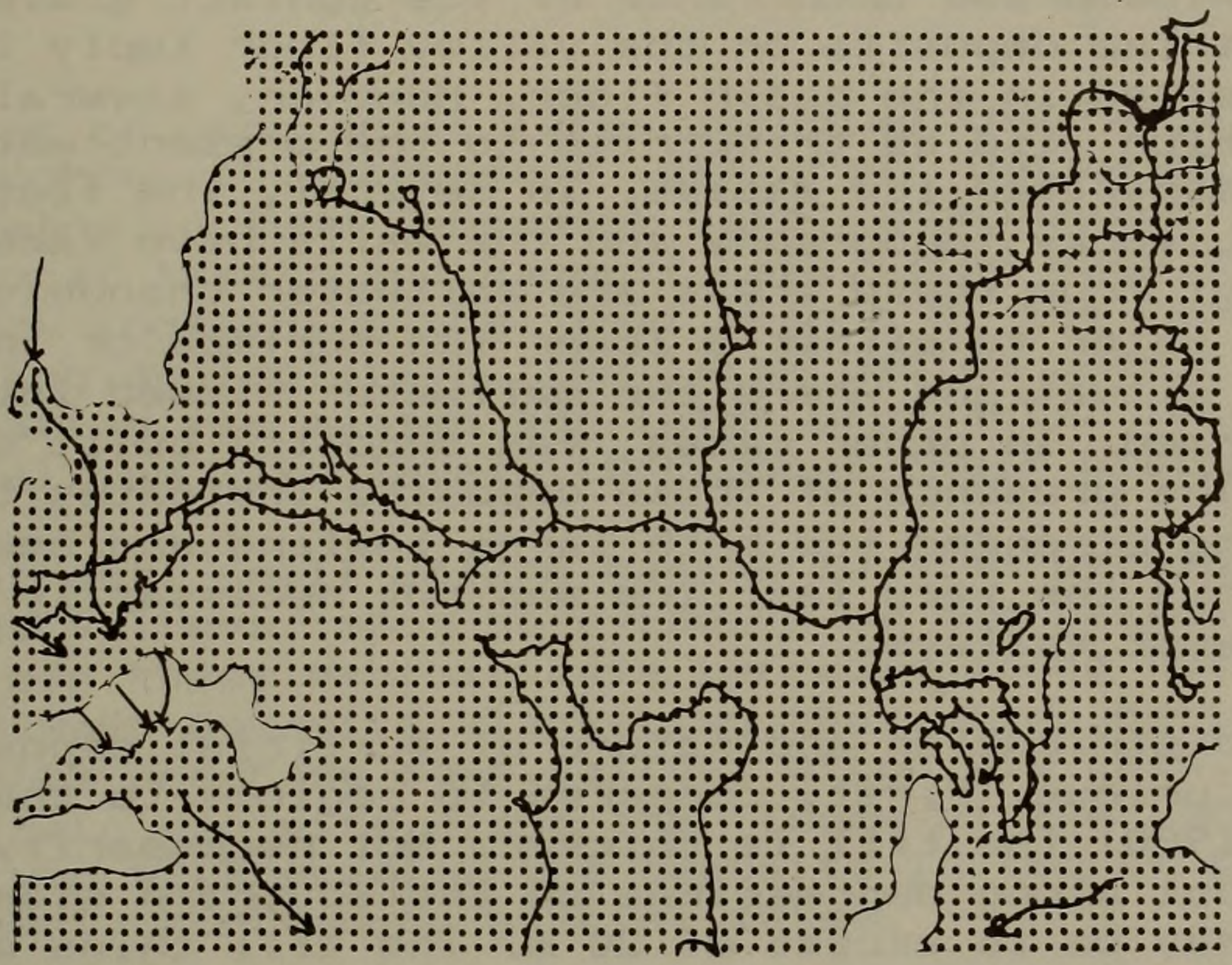


Figure 4a. Stylized sequence representing former ice and proglacial lake positions during deglaciation. Dot patten is ice cover; horizonal lines are lake extents. See Figure 1 for location names and scale. This figure shows southward meltwater drainage phase.

Figure 4b. Eastward drainage controlled by basin topography.

The widespread occurrence of ice contact gravels, kettles and lacustrine deposits on the valley floor imply that the last ice had melted in the basin floor. However, several small upland valleys which lie as tributries to the present waterways also retained separated ice masses. In several, the flat floors contain hummocky topography and the walls have kame terraces. Leading out from these areas are meltwater channels which conducted water to either a lower ice surface or into proglacial lakes. In situations where the meltwater flowed into lakes small deltas formed. In other cases, fan deposits built at the base control. The presence of these deposits indicates that the downwasting stranded ice both large lowland and small upland basins. Thus the very last ice was not necessarily at the bottom of the lowest valleys.

The distribution and nature of surficial deposits is somewhat curious. First, compared to regions to the north (Lowell, 1980) the till is thicker. Not necessarily as a uniform blanket, but along depressions on the southern sides of hills, the till may be in excess of 20 m. The till thins as it laps onto the hill slopes and the hill tops expose bedrock. The presence of meltwater channels also has some relationship to the till distribution - the most common and best displayed channels occur lower on the hill slopes where the till is thick enough to be eroded.

Like the more abundant till, gravel deposits are more common in the Seboomook area than in the more northerly Allagash region. Gravel fans constitute the largest volume of stratified material in the area. Of course, abundance is relative; compared to the Allagash region the stratified deposits are large. However, when compared to the marine deltas, eskers, and outwash plains of southern Maine, they are insignificantly small. This impression may not be well conveyed, because the field trip visits the largest pits in the region.

This becomes more interesting when one considers that a fair measure of all the gravel probably originated from erosion as meltwater cut channels into the till. It seems then that the supply of englacial debris was small indeed in northwestern Maine - something one would expect near the center of an outflowing ice mass, but not from the outer portion of a large ice sheet.

## LAKE BASIN HISTORY

A series of proglacial lakes occupied the large lowland basins throughout the Seboomook Lake area. The major basins discussed below include Seboomook Lake, (now dammed); Lobster Lake,(a natural lake); and Ragmuff Lake, (the name assigned to the basin now containing the West Branch of the Penobscot River). During deglaciation, the large basins commonly contained first stagnating ice masses and later proglacial lakes which exhibited falling lake levels throughout their history.

In contrast, small upland basins located within tributaries to the large valleys, show no evidence of occupation by former lakes. Instead these exhibit kame terraces along the valley sides and thin outwash deposits blanketing the valley bottoms. Some of these deposits prograde down valley, often via cols, and end in fan and deltaic deposits along the floors of the large basins. The field trip will examine the deposits in two of the large basins formerly containing glacial lakes.

### Glacial Lakes Seboomook I & II

Damming of the West Branch of the Penobscot River created the present Seboomook Lake. This basin is relatively narrow and steep sided in comparison to other basins in the region and gives evidence for a complex history of ice down-wasting: final stagnation took place in the valley bottom and two different lake levels are present. The highest level (Glacial Lake Seboomook I) is evidenced by a delta with a topset-foreset contact of 340 m (1114 ft) a.s.l. and rhythmite sediments deposited to 336 m (1102 ft) a.s.l. (Stop 2). A second lower lake level, Glacial Lake Seboomook II at 331-333 m (1085-1091 ft) is indicated by two flat landforms (one exhibiting a topset-foreset contact) built into the lake. The lowest deltaic deposition may be associated with the valley fill in the North Branch of the Penobscot River (Stop 4) based on a calculated gradient of 2.7 m/km between the tops of the two features. All deltaic landforms are kettled and associated with hummocky topography, suggesting an ice-contact environment for both these lakes.

The exact drainage pathway for either of these lakes is unknown. Several possibilities exist and the two lakes may have shared the same outlet or had different outlets. Two channels - at 327 m (1071 ft) and 315+ m (1020+ ft) a.s.l. - exist between Seboomook Lake and Moosehead Lake to the south. However, marginal channels and kame terraces suggest that a stagnant ice mass existed in the Moosehead Lake basin and the eastern portion of the Seboomook basin at approximately 336 m (1100 ft), effectively blocking drainage to the south (Fig. 4c). Another alternative is that the water could have drained eastward through the same channel that the West Branch of the Penobscot River utilizes today. Lastly, the water may have drained eastward via a channel that leads from the Seboomook basin parallel to the modern

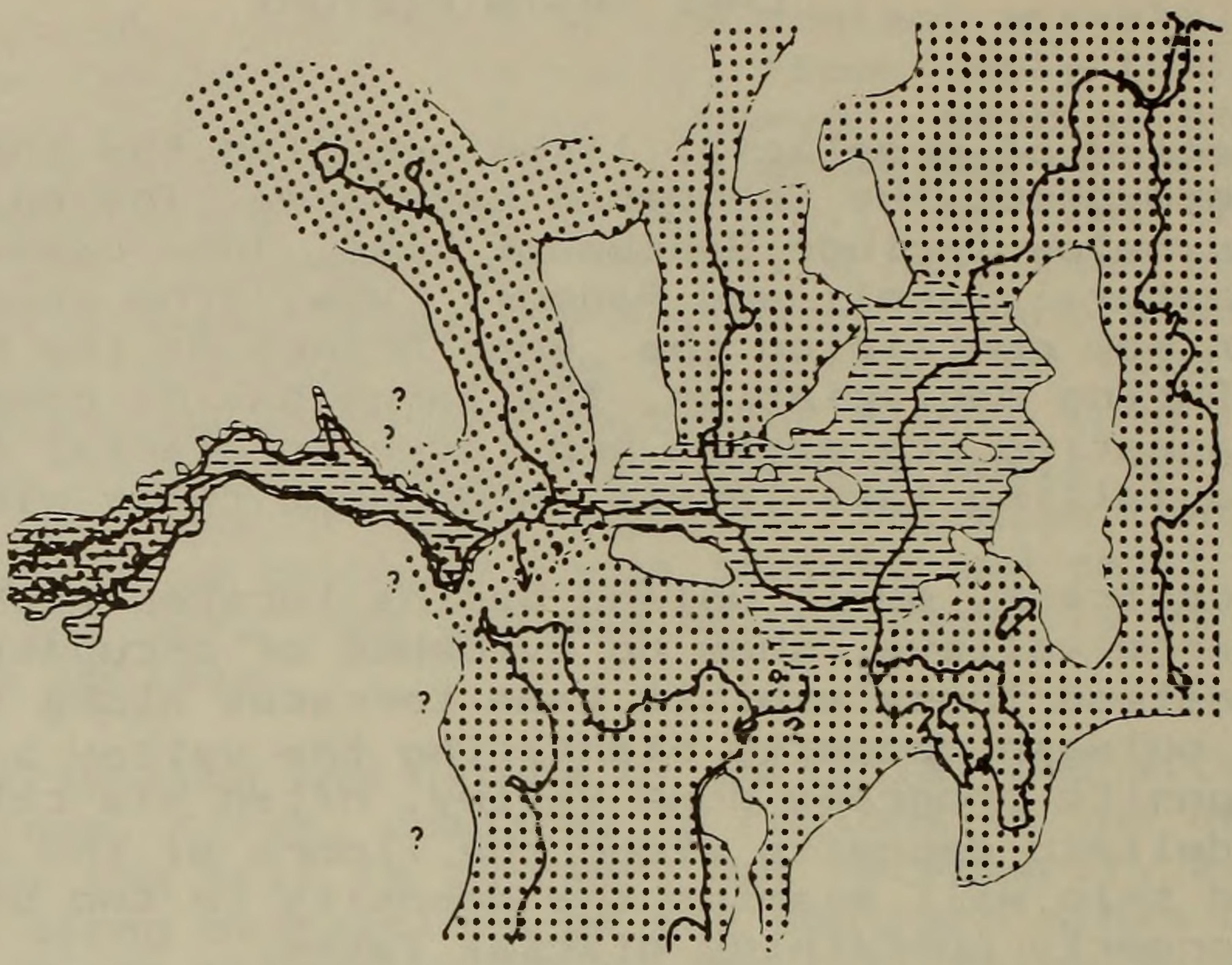


Figure 4c. Glacial Lake Seboomook I & II and Glacial Lake Lobster. Lake levels near 340 m. Relationship of Glacial Lake Seboomook and Glacial Lake Lobster not known.

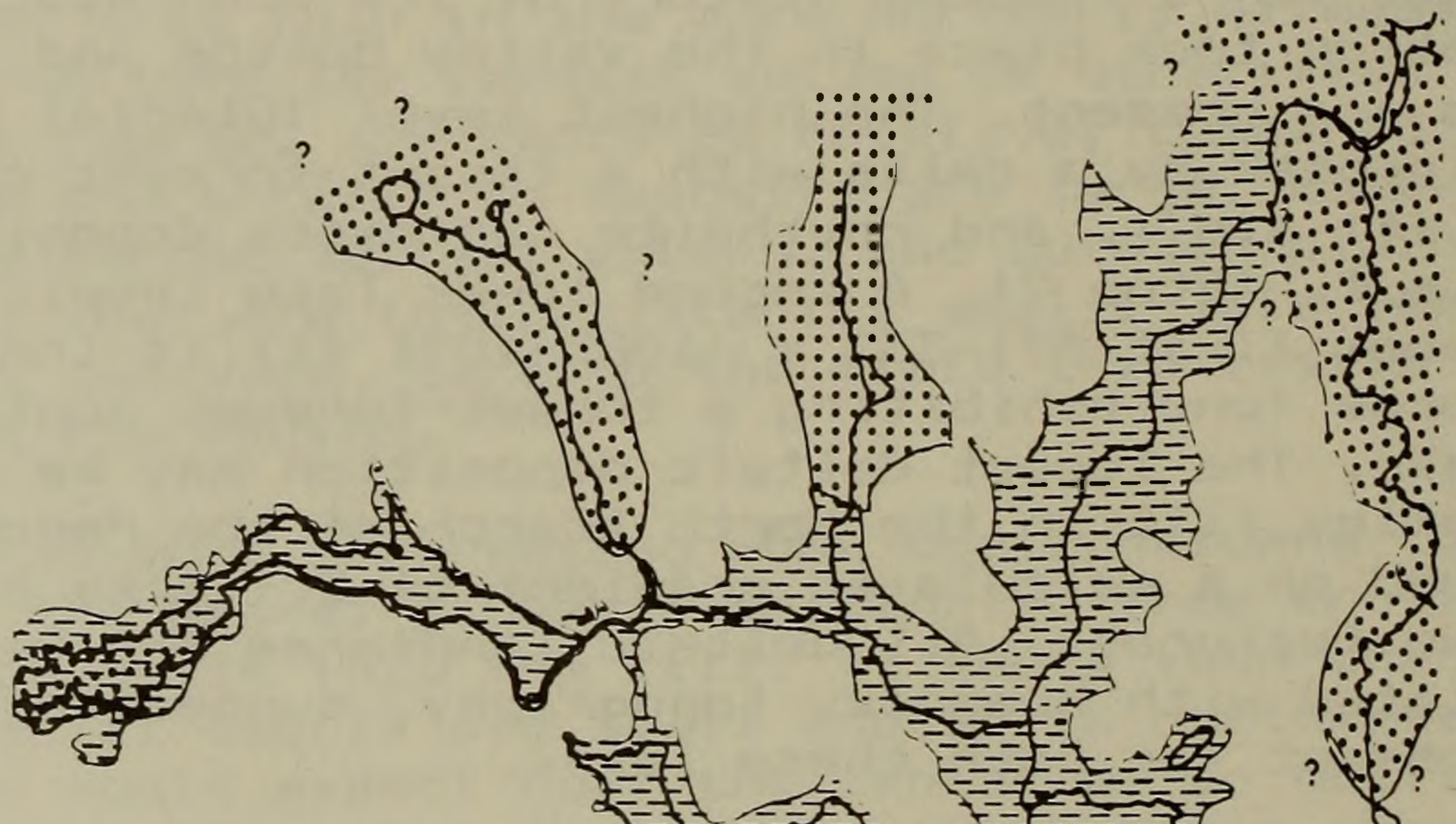


Figure 4d. Glacial Lake Seboomook I & II (340 m) and Glacial Lake Ragmuff I (336 m). Possible drain for Glacial Lake Seboomook and Glacial Lake Ragmuff via paths represented by arrows.

Penobscot River. This channel begins at 336 m just above the east end of the lake and terminates at approximately 320 m. a.s.l. (Fig. 4d). If this channel was used as a spillway it indicates that the Seboomook Lakes would have drained into Glacial Lake Ragmuff I, which is lower than either Seboomook glacial lake.

## Glacial Lake Lobster

Three successive lakes occupied a broad gently sloping basin which presently contains Lobster Lake, Little Lobster Lake, and the West Branch of the Penobscot River between Seboomook Lake and Chesuncook Lake (Fig. 1). Outlets from this basin include two low passes into the Moosehead Lake basin at approximately 314 m (1030 ft) and 320 m (1050 ft) as well as the modern valley extending towards Chesuncook Lake.

The highest lake in this series is designated Glacial Lake Lobster. This proglacial lake was confined to the basin of the West Branch of the Penobscot River as far north as Smith Halfway House, and extended into the basins of Lobster Lake and Little Lobster Lake if these were ice free (Fig. 4c). The limited evidence for this lake consists of rippled and rhythmically bedded sands found approximately 336 m (1110 ft) a.s.l. on the hill slopes of this basin. Ponded water at this elevation requires dams both to the south and to the north. The previously discussed ice block in Moosehead Lake, as well as an ice mass in the Chesuncook Lake basin, is hypothesized to provide such a base level control. Smith Halfway House was chosen as the northern margin of Glacial Lake Lobster based on field evidence of eroded ice-contact deposits at this natural constriction in the basin and because no evidence of this high lake level was found north of that location (Fig. 4c).

Whether Glacial Lake Lobster was continuous westward into the Seboomook Lake basin is problematic. Both Glacial Lakes Seboomook I and II existed at approximately the same elevation as this lake. However, no continuous shorelines or deposits can be traced from one basin to the other. The previously described channel between the two basins, as well as mapped deposits of till and ice contact stratified drift along the narrows between the basins suggest that a stagnant ice block may have separated the two lakes (Fig. 4c).

## Glacial Lake Ragmuff I

Several pieces of evidence delimit the margins of the next lower lake, Glacial Lake Ragmuff I, in this basin. Shoreline features including lag gravels and washed bedrock knobs, as well as various exposures of rhythmically bedded sands, suggest a water level of 320 m (1050 ft) in a basin extending north to at least Chesuncook Lake. This lake also requires a dam at both its north and south ends. This could be accomplished by ice in both the Moosehead and Chesuncook basins or by higher lake levels in both basins or by some combination of the two.

To the south, such a lake could have been continuous with the Moosehead Lake basin through three different passes: west from Lobster Lake, and south from the Penobscot River via two lowlands (Fig. 4d). A flat landform composed of pebble gravel at approximately 320 m (1050 ft) a.s.l. is found along the northeast shore of Moosehead Lake and traces into outwash up a tributary valley. This may represent the extension of Glacial Lake Ragmuff I into the Moosehead Lake basin.

To the west, Glacial Lake Ragmuff I was separated from the Seboomook basin because present topography rises above this lake level. The previously discussed channel feature originating at 336 m in the Seboomook basin and dropping to 320 m in the Lobster basin may imply contemporaneity of Glacial Lake Seboomook with Glacial Lake Ragmuff I (Fig. 4d).

## Glacial Lake Ragmuff II

Glacial Lake Ragmuff II, the lowest lake, has deltaic features at the mouth of Luther Brook (Stop 9) and along Pine Stream (Hanson, unpub.) which measure 309-310 (1013-1018 ft) a.s.l. (Figs. 1 and 4e). These suggest a continuous water body from Lobster Lake to Pine Stream Flowage. The highly kettled delta in Pine Stream Flowage suggests that stagnant ice lay in this arm of Glacial Lake Ragmuff II. Because ice is present at this time, it implies that the previous lake (Glacial Lake Ragmuff I) also formed against an ice margin in the Chesuncook Lake basin (Fig. 4d).

Glacial Lake Ragmuff II extended into Lobster Lake and Little Lobster Lake, but had dropped below the spillway into Moosehead Lake (Fig. 4e). Thus its base control shifted north to the Chesuncook basin where it must have been dammed by ice or become continuous with a higher level Chesuncook Lake.

## Fan Deposition and Riverine Terraces

Located at the mouths of several tributary valleys are fan deposits built into the glacial lakes. These tributary valleys contain a thin veneer of gravel along their floors. The gravels commonly extend down valley (often through cols) and end in fans and/or deltas. For example, evidence from Luther Brook (Stops 8 and 9) suggests that the fans were deposited into Glacial Lake Ragmuff II and at the same time eroded rhythmites previously deposited by higher lake levels. At Luther Brook the deposits shoe shallow deltaic stratigraphy, but more usually the fans exhibit braided channel, sieve, and plug deposits as well as imbricated cobble gravels. Throughout the field area, the indicators in these landforms consistently show flow into the large basins (rather than along their sides) and individual landforms begin at different elevations along the valley sides.

As such, these landforms have been mapped as fan deposits and constitute a major portion of the gravel within the field area. The distribution of fans suggests that some upland basins contained the last ice remnants.

Subsequent to fan deposition the rivers in the bottoms of the large lowland basins reworked the fan gravels into alluvial terraces. This interpretation stems from the observation that the lowest lying gravel deposits in the basins occur only in association with tributary valleys; rhythmically bedded lacustrine sands blanket the large areas between tributary valleys.

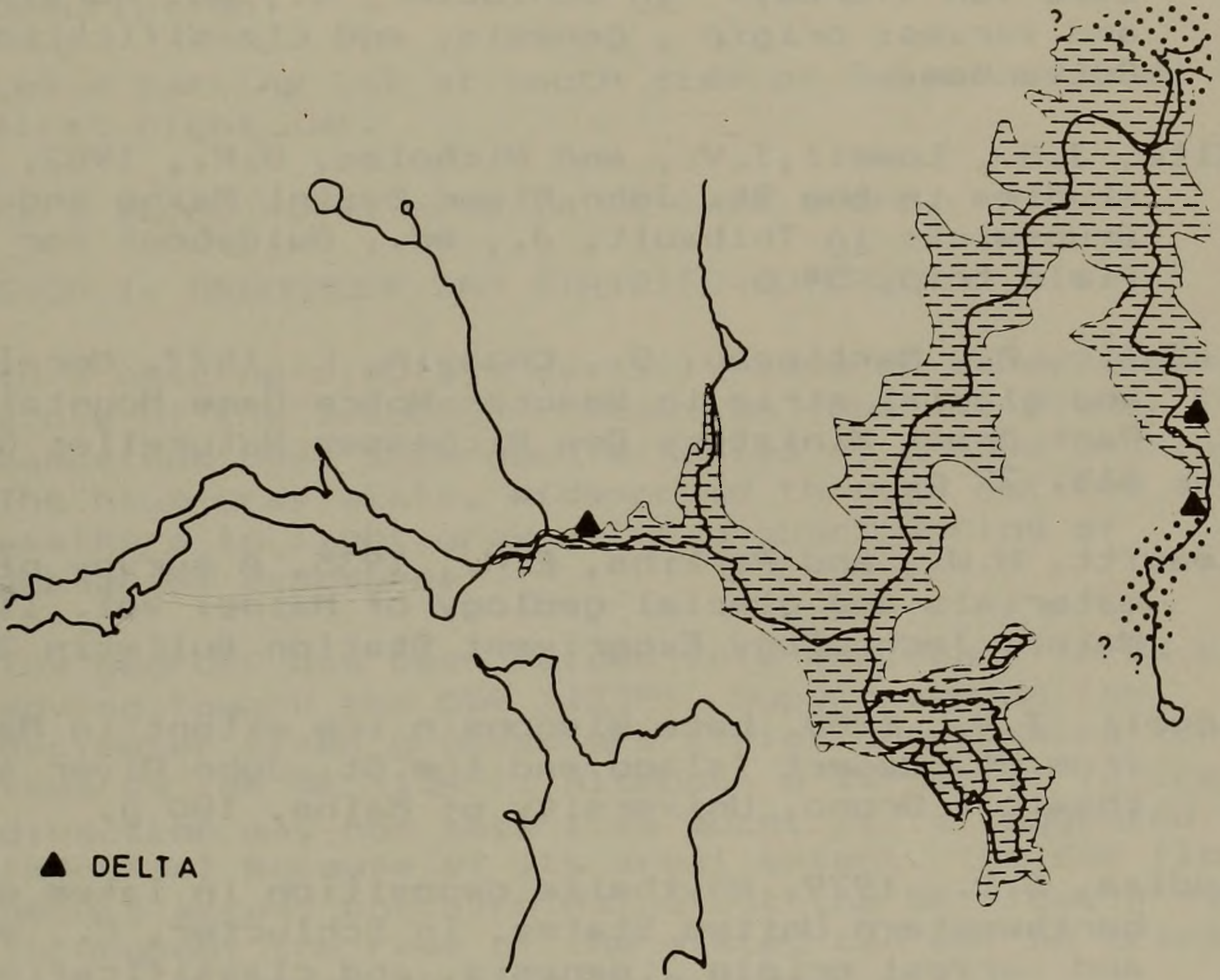


Figure 4e. Glacial Lake Ragmuff II (309 m). Location of deltas shown.

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## ROAD LOG

Mileage Description

0.0 Leave parking lot at south side of Seboomook Dam. Take first right (W).

0.3 Park along road, stop is on lake shore.

### STOP 1: SEBOOMOOK DAM STRIATED OUTCROP

This outcrop displays cyclicly-layered sandstones and slate of the Seboomook Formation (Boucot, 1969). The sandstone beds show good examples of graded bedding. The blue-gray slate, widespread through out the area weathers to light gray after a short period of subaerial exposure.

The bedrock has been molded into whaleback forms by ice moving toward the ESE (122°). Superposed on the decimeter sized grooves are striations showing ice-flow towards the SE (154°). Although a 22° shift in ice-flow direction may not seem like much, it is suggested to be important because of its areal extent. The ESE flow occurs across northern Maine but the SE flow, present throughout the rest of the state, can not be traced much further north than this area.

How does this flow relate to the glaciation of the region ? If a southeastward flood of Late Wisconsin Laurentide ice is used to explain it, then why is it not present further to the north ? Alternately if the first Late Wisconsin ice-flow is to the ESE then the SE flow may relate only to ice covering Maine, not Laurentide ice. This problem requires discussion.

0.5 Pass Seboomook Dam campsite.

1.5 Keep left (S).

2.2 Turn right at access to Seboomook store.

5.7 Seboomook / Boyd east townline.

10.5 Pass 7 Mile Hill campsite.

11.6 Keep right to cross Beaver Brook (left goes toward Greenville). The flat area to the north consists of pebble gravel and may be a delta or outwash at 330 m (1085 ft) a.s.l.

12.7 Boyd east / Boyd west line.

14.1 Keep right at road to Greenville. Turn right (N) and take western road. Drive to and through campsite. Stop along lake shore.

## STOP 2: RHYTHMITE SECTION AT SEBOOMOOK LAKE CAMPGROUND

This stop is located along the south shore on the southwestern corner of Seboomook Lake. The section is contains 7-9 m of massive and laminated sands and silts. It extends laterally 0.1 km towards the northwest where it is interbedded with or overlaps a mound of cobble gravel which may be an esker core (see Fig. 5).

The 8 m wide section to be examined on this trip is located on the west side of the larger section, and consists of three major units. The lowest unit consists of interbedded gray and tan sands with soft sediment deformation, loading, and faulting exhibited along a dipping upper contact. Rhythmically bedded sands and silts overlie the lowest unit which contains ripples, graded beds, and silt drapes. A maximum of 146 rhythmites have been counted in an adjacent section. The uppermost unit consists of massive tan sands. The unconsolidated portion of the section overlies pillow basalts of the Canada Falls Volcanic Member (Marvinney, 1983) which have well shaped ice-flow indicator showing former ice movement toward 142°.

The rhythmites are interpreted as lake bottom deposits. Underflows are responsible for the rippled and graded beds whereas deposition from suspension produced the sandy beds and silty drapes. The massive sand located at the top of the section is interpreted as shallow water lacustrine deposition in which the laminae have been disturbed by wind-generated turbulence, seiches, burrowing organisms (Ludlam, 1979) and/or convection of the epilimnion (Kempe and Degens, 1979). An added possibility to explain the lamination disturbance is mixing by frost and tree root action subsequent to lowering of the lake level.

This section crops out 0.1 km from a Gilbert-type delta composed of 1 m trough-cross bedded cobble gravel overlying 6.5 m dipping pebble sand beds. These beds dip at 11-20° and indicate water flow towards the east (78°) and northeast (47°). The topset-foreset contact of the delta measures 340 m (1114 ft) a.s.l. and indicates the water level at the time the delta was deposited. The top of the delta contains kettles, suggesting it was deposited over stagnant ice in the basin. The coarse sands exposed at the base of this section possibly formed in an ice contact environment prior to the formation of the rhythmite beds.

Bedrock knobs abut both sides and underlay this

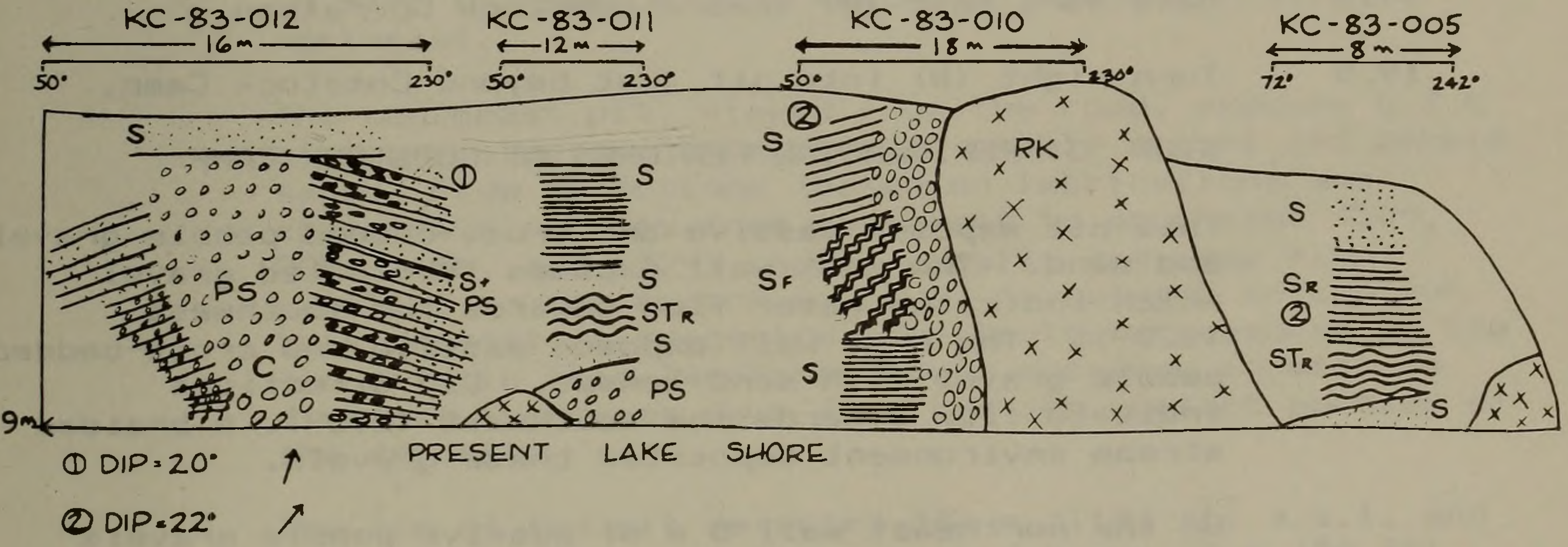


Figure 5. Rhythmite section of Stop 2. Stop will examine extream right hand side of exposure (KC-83-005). Legend for this and following figures: c/cg = cobble gravel, ps = pebble sand, = rippled beds, rk = bedrock, s = sand, st = silt. Circles numbers refer to current measurement locaties; arrow represents azmiuth of water flow. Scale and bearing of sections along edge of drawings.

rhythmite section. Bedrock exposures are a common feature all along the shoreline of Seboomook Lake, but only in the shallow western basin of the lake are the intervening areas between the knobs filled by lacustrine and ice contact sands and gravels.

14.6 Return to main road, turn right (W) to cross causeway.

15.4 Pass entrance to BSA Wilderness Base.

15.6 Cross South Branch of the Penobscot River.

15.9 Exposure in delta. Here 1.5 m of massive cobble gravel overlies 2.7 m of sand which dips 25° towards the east (113°). The topset-foreset contact is 333 m (1091 ft) a.s.l. and indicates a lower lake level than the rhythmites and delta at Stop 2.

16.0 Keep right (NW) at road to Canada Falls.

17.4 Pass Lane Brook campsite.

17.7 Turn right (N) at sign for North Branch.

19.3 Make hard left (W) toward Comstock Operation.

19.5 Turn right (W) into pit just beyond Comstock Camp.

## STOP 3: PERIGLACIAL FEATURES AT COMSTOCK CAMP

This pit exposes massive and cross-bedded pebble gravel and sand. The west wall exposes imbricated gravel which indicates water flow towards the southwest (225°). The east wall exposes massive and cross-bedded pebble gravel with sand lenses. Dip directions indicate flow towards the southwest (205°). A braided stream environment deposited these gravels.

On the northeast wall 5 m of massive pebble gravels have kink folds and vertically aligned clasts that cut the horizontal beds. Compression from an enlarging ice wedge and summer expansion against it may explain the folding of the pebble beds adjacent to the vertical pebbles. Slump and subsequent melting filled the wedge with vertical pebbles. Thus cryoturbation and fossil ice wedge casts would indicate a former permafrost environment here. Periglacial features have been recorded for other scattered locations in northern Maine (Lowell, 1980; Newman, pers. comm., 1981; Kite, pers. comm., 1982).

Turn around, head north past Comstock camp.

20.2 Cross bridge at Leadbetter Falls. Note horizontal bedding in pit exposure.

20.4 Turn left (W) and drive along top of pit.

20.7 Turn left (W) into pit.

## STOP 4: TERRACE DEPOSITS AT LEADBETTER FALLS

Two pits are exposed in this deposit which constitutes the lowest glacial landform in the valley of the North Branch of the Penobscot River. The landform abuts the valley wall on the east and has been eroded by the river to the west (a terrace step is eroded into the landform along the west side of the northwestern pit).

The northwest pit (this stop) contains 12.5 m of massive, aligned, and cross-bedded cobble gravel and pebble sand (see Fig. 6). Dipping beds indicate water flow towards the south (174°) and southwest (228°), while ripples within sandy lenses indicate flow towards the southeast (131°) and west (282°). Flow parallels the modern valley. High angle faults, a filled kettle, and the steep ice contact face of the pit indicate outwash deposition over and adjacent to ice. The large scarp on the northwest portion of the landform is due, in part to erosion by a meltwater channel from the northeast.

The southeast pit, viewed from the road, exposes 6-7 m of imbricated and cross-bedded cobble gravel and pebble sand. Flow directions (based on imbrications and apparent dip) vary from northeast to southeast (50°, 90°, 115°, and 132°), but generally indicate flow parallel to the modern valley. An outwash origin for this deposit is suggested. The boulders measured in the two pits in this landform show a decrease in size as distance increases away from the ice contact portion of the deposit.

The top of the pit measures 348 m (1141 ft) a.s.l. and indicates a valley fill estimated to be 15 m (50 ft) thick. This feature is unique in the region and suggests that valley trains did not commonly fill the valleys and later erode to form valley terraces.

21.0 Return to main road, turn left (N).

21.6 T4 R18 / T4 R17 town line.

21.8 Turn left (NW) at stop sign onto the Golden Road.

22.0 T4 R17 / T4 R18 town line. Note numerous pits along roadway.

25.3 Pull into pit with canvas shed.

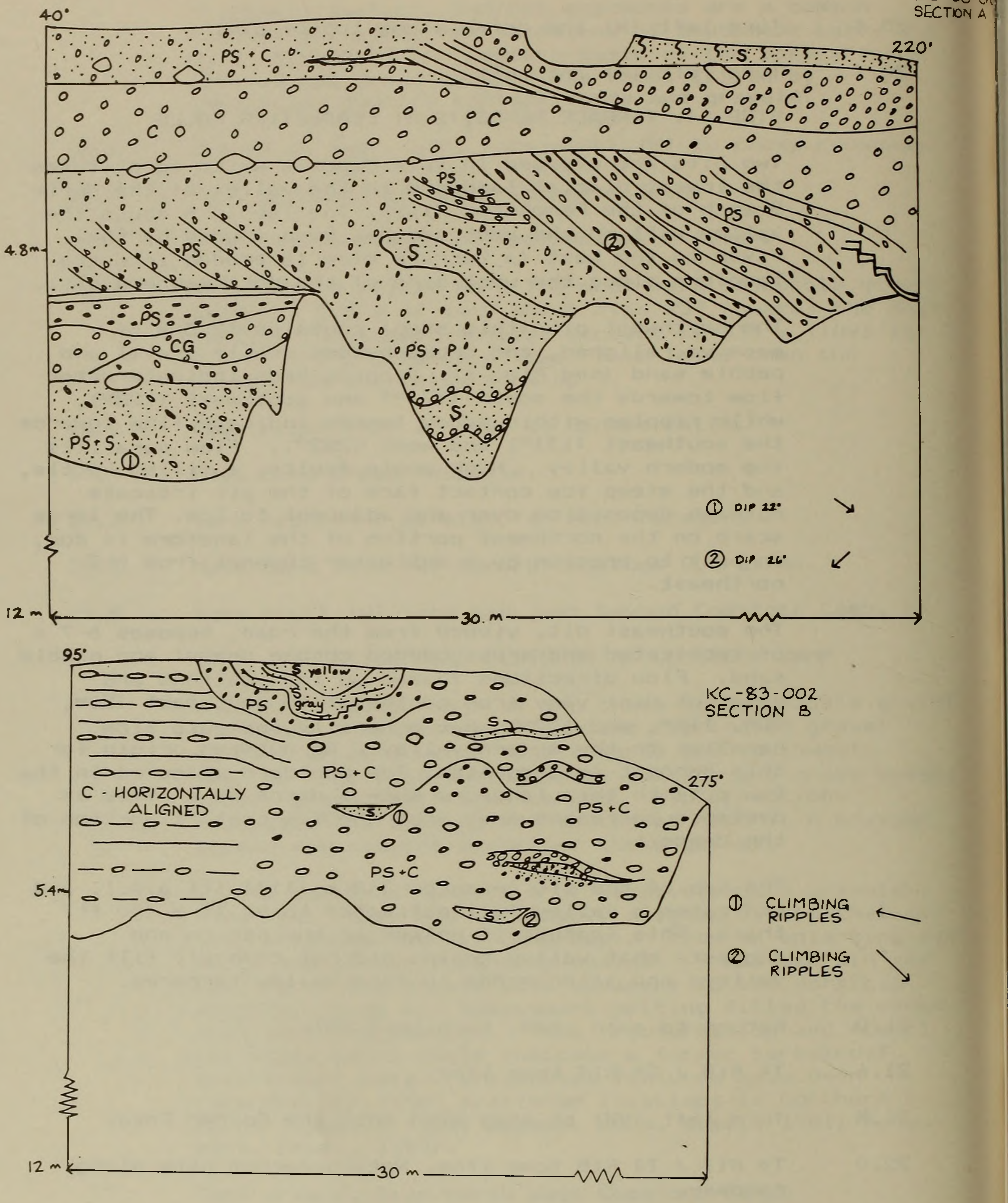


Figure 6. Pit exposure at Stop 4. Legend same as Fig. 5.

## STOP 5: FAN DEPOSIT AT SPENCER BROOK

This 10-12 m thick deposit sits above the east side of the North Branch of the Penobscot River. Massive cobble gravels and pebble sands are interbedded with rippled and cross-bedded sands and pebble sands. Dipping beds and ripples indicate flow towards the southwest (225°) ie. into the present valley. A small kettle can been seen near the center of the pit. This gravel deposit overlies till exposed lower in the valley wall approximately 0.25 km southeast of this pit.

The landform is interpreted as a fan deposited by Spencer Brook. This fan lies at the same elevation, 366 m (1200 ft), as another similar deposit 3.5 km further north up the valley. This second smaller fan lies at the mouth of Bog Brook, but both fans appear to emanate from the same upland basin and may have been fed from a stagnant ice mass melting there.

A third 366 m (1200 ft) landform occupies the center of the valley north of Bog Brook and has an ice-contact face along its north side. The consistent elevations of the three landforms suggest a deltaic origin, but no clear deltaic stratigraphy is exposed in any of the sections. Therefore, these deposits are interpreted as fans built into standing water as described by Axelsson (1967). Plugs of boulders, imbricated cobbles, channel deposits and sieve deposits present within described sections through out the valley substantiate the fan hypothesis (Reading, 1978).

Such fan features are common to all basins in the field area and several have been mapped along the north shore of Seboomook Lake. However they are thin and cover the hillside with a blanket morphology. The interpretation of these features as fans is based on the following evidence: 1) the gravel deposits become thinner towards the north (upslope), 2) the grain size of the deposits coarsen towards the north (upslope), 3) the apices of different deposits begin at different elevations above the lake, 4) the flow indicators consistently show flow into the lake basin, and 5) these features cannot be traced into a flat continuous terrace that parallels the lake shore. Additionally, the fans are commonly fed from cols containing channels that end upstream in small basins where ice blocks could have produced the meltwater to feed the fans.

26.2 Pass good exposure of bedrock on the right and point bars on the left.

27.3 Turn left (NW) at Snake campsite.

### LUNCH STOP: SNAKE CAMPGROUND ON THE NORTH BRANCH OF THE PENOBSCOT RIVER

Note the imbricated gravels in the stream bank and the silty alluvium which overlies them in a filled meander scar north of the picnic area.

28.2 Return to the Golden Road, turn right (SE).

33.7 Return to junction at mile 77, continue east.

34.5 Turn right onto "Com 1".

35.1 Park at small turnout on left (E) side of road.

### STOP 6: CHANNELS ON NORTH SHORE OF SEBOOMOOK LAKE

The road runs along an interfluve between two submarginal channels that are cut into thick till. The incision is approximately 30 m; the channels begin near 410 m and end at the 350 m level. This is one of four channels on the northwest side of Seboomook Lake. At their upper end they parallel contours for a few hundred meters before they dive downslope in a zig-zag pattern for distances up to 2.5 km.

The channels may emanate from downwasting ice which fills the basin to the 410 m level. Meltwater freely drains towards the bottom of the ice where it intersects a base control (piezometric surface). These features represent a late phase of deglaciation because any englacial meltwater flow above the 365 m level could pass through high cols out of the basin in a southerly direction. However, once the base level drops below this level it must move eastward paralleling modern drainage, through the basin.

One interesting aspect of the submarginal channels in this area is that a smaller submarginal channel obliquely crosses the tops of the larger channels. The relative age of these features is problematic.

35.7 Return to the Golden Road, turn right (E).

36.1 Turn right (S) onto "Seboomook Loop Road".

38.3 Road drops from thick till onto channel floor.

39.3 Turn right (S) onto unmarked road. Note topography.

39.7 Note rock scarp and Pittston Farm to right (SW).

40.0 Park at end of road.

## STOP 7: HUMMOCKY TOPOGRAPHY ON THE NORTH SHORE OF SEBOOMOOK LAKE

Depositional hummocky topography consisting of gravel hummocks and ridges with kettles comprise the landscape here. These drape over bedrock knobs which also show fair relief. This topography occurs ubiquitously in the western portion of Seboomook Lake basin. Although some ice contact gravels extend to levels of 365 m (1200 ft) and higher in some valleys, the major concentration is at 335 m (1100 ft). a.s.l. These deposits lie directly across the lake from the rhythmite section (336 m a.s.l) examined at Stop 2 and the kettled delta (341 m a.s.l) adjacent to it.

This suggests a period in the history of this basin when sediment was being deposited over stagnant ice blocks and building a delta into the basin. Contemporaneous with or slightly following this event, sandy and silty rhythmites were deposited into the same area of the lake basin while the water level remained at an elevation of at least 336 m (1102 ft) a.s.l.

| | |
|---|---|
| 40.7 | Return to Seboomook Loop Road, turn right (E). |
| 41.0 | Note pit in ice contact drift on left (N) side. |
| 41.6 | Note Seboomook Lake on right (S). |
| 41.9 | Pittston / Boyd west town line. |
| 43.2 | Return to the Golden Road, turn right (E). |
| 46.1 | Boyd west / Boyd east line. |
| 49.7 | Cross Nulhedus Stream. |
| 51.9 | Note 4 way intersection (southern road leads to Seboomook Dam). |
| 55.2 | Pass road north to St. John Operation. |
| 57.3 | Seboomook / Burbank town line. |
| 57.4 | Turn right (S) onto unmarked road just before rock crop. |
| 57.6 | First part of stop (A) is exposure on right (W). Remainder of stop (B) is in this pit further to the west. |

## STOPS 8 & 9: LACUSTRINE SEDIMENTATION AND EROSION AT LUTHER BROOK

These last two stops examine three separate exposures in a single landform at the mouth of Luther Brook, a southward draining tributary to the West Branch of the Penobscot River. The stratigraphy of the two stops will be described separately, followed by an interpretation which includes both stops.

STOP 8

The first section (east end of pit) consists of 1.77 m of rhythmically bedded sands and silts. The laminae vary in thickness from 20 to 85 mm and include ripples, drapes, and graded beds. The base of the section shows thicker sandy beds with silt drapes, while thinner silty rhythmites overlie them. The uppermost beds are mottled silt devoid of structure. Prior to pit excavation, a thin cobble gravel may have been the top unit (see Fig. 7).

The second section (west end of pit) is composed of 30 cm pebble sand which contains cobbles and which overlies 1.5 - 2 m sand beds dipping towards the south (162°). The contact is 309 m (1013 ft) a.s.l. Below the dipping beds are sands containing assorted pebbles and clasts of silt, sand, and gravel which have been interpreted as rip-up clasts. This lowest unit underlies the foresets in the west wall of the pit but is best exposed in the gullies on the south side of the pit.

58.2 Return to the Golden Road, turn left (W).

59.0 Pass road 19A to north.

59.2 Turn left onto unmarked road.

59.5 Park at corner.

STOP 9

This section contains 3.2 m of cross-bedded pebble sand and gravel overlying rhythmically bedded sands and silts. The rhythmites vary in thickness from 50 to 95 mm, and are interpreted as lake bottom deposits. The pebble sand, which includes cobble gravel, overlies an erosional contact which truncates the horizontal laminae of the rhythmites (see Fig. 8a). The truncated surface is 306 m (1002 ft) a.s.l and the top of the gravel section is 309 m (1012 ft) a.s.l.

The rhythmites are commonly sandy beds with silty drapes, graded beds, ripples, and soft sediment deformation. One lens of coarse gravel is included in the rhythmites. These beds vary laterally to a silt/clay pod. An soil auger hole shows the pod to be 66 cm thick and overlies at least 10 cm of coarse sand

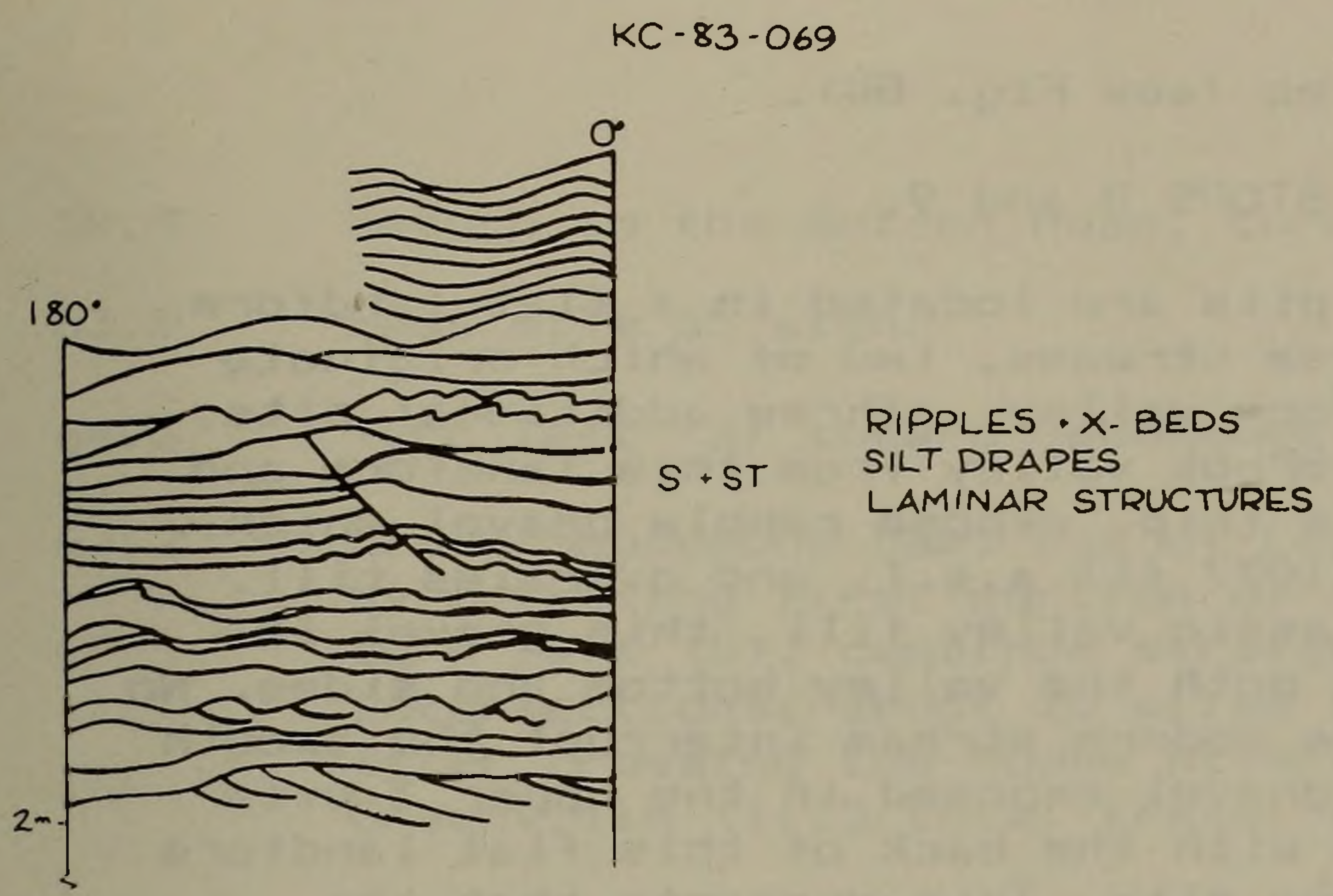
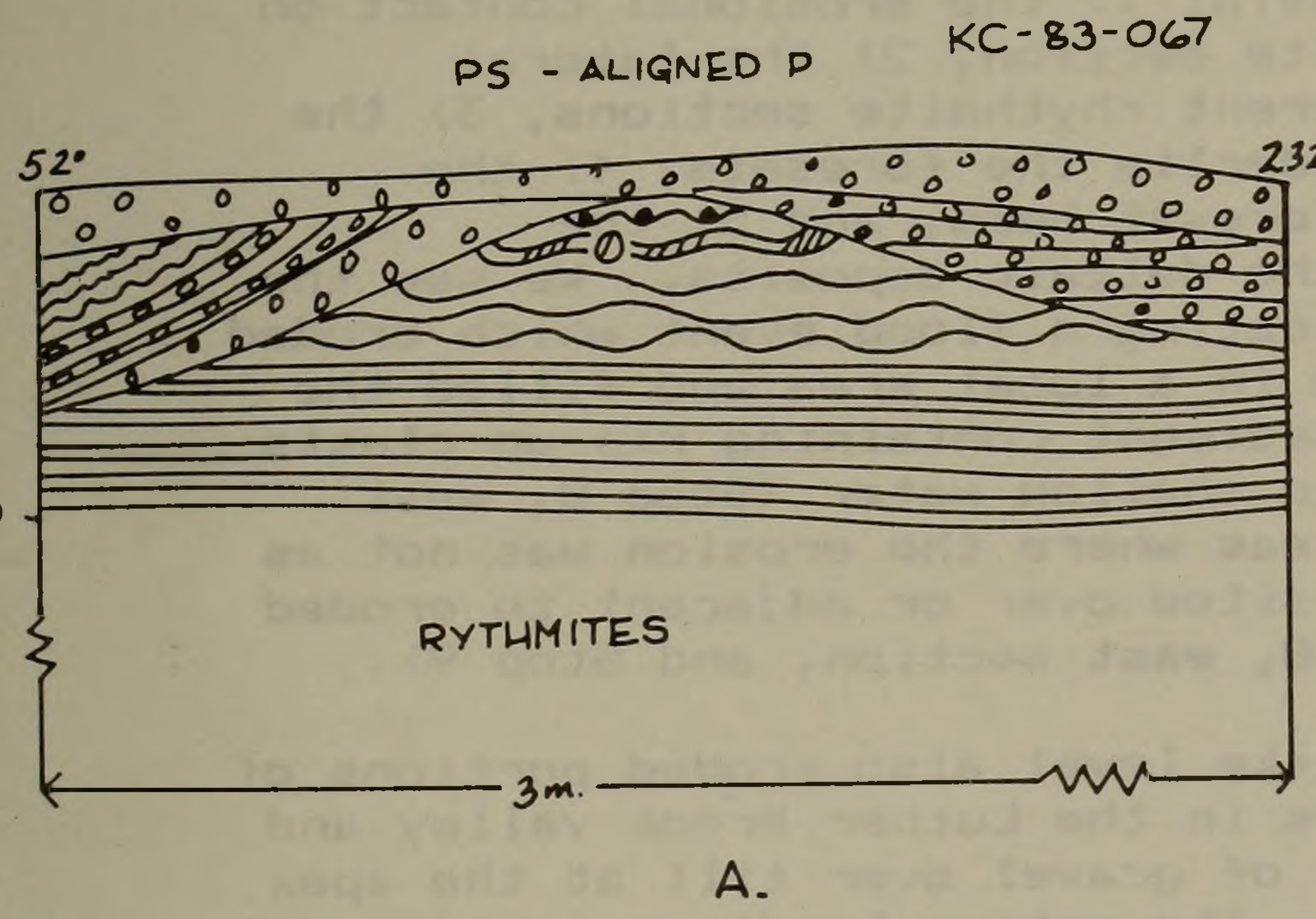


Figure 7. Exposure at Stop 8a.

Lake bottom sediments.

Legend same as Fig. 5.



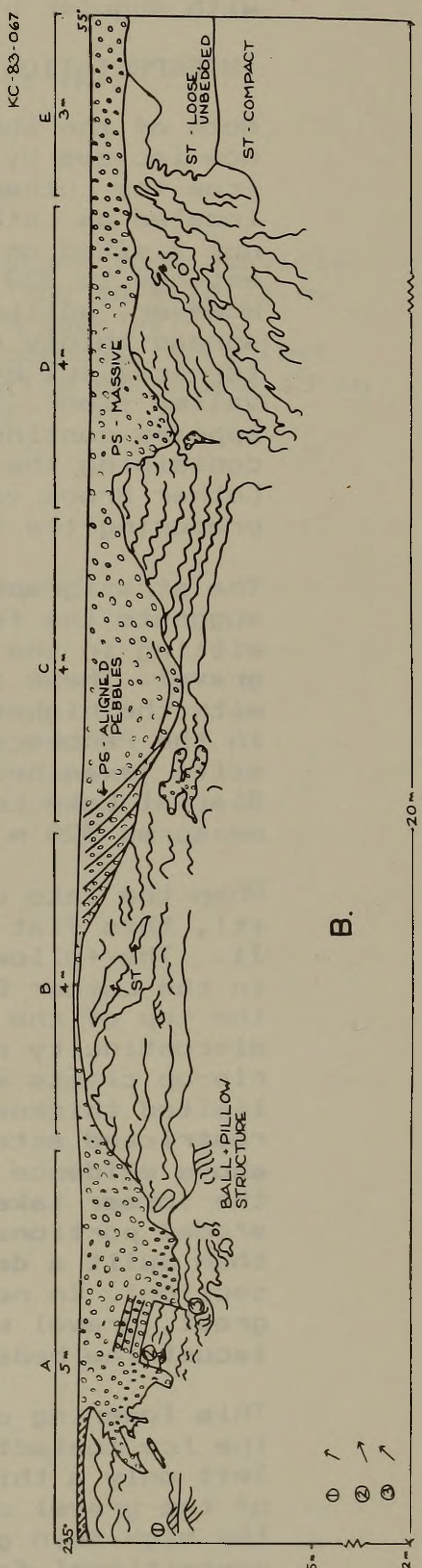


Figure 8a,b. Exposures at Stop 9. Legend same as Fig 5.

with angular pebbles (see Fig. 8b).

INTERPRETATION OF STOPS 8 and 9.

Both of the above pits are located in a flat landform now incised by three streams, two of which originate from the Luther Brook valley. Three additional pits, located up Luther Brook valley from this landform and not visited on this trip, expose pebble gravel which extends to 328 m (1077 ft) a.s.l. and overlies till. However, unlike classic valley fill, this gravel is spread thinly over both the valley bottom and sides. No terraces cut by the modern stream interrupt the smooth valley floor. The gravel exposed in the upper 3 pits appears continuous with the back of this flat landform containing the lower pits. This suggests that the Luther Brook valley was the source for the gravel producing the flat landform.

The stratigraphy exposed in the entire landform suggests the following history. First ice blocks sitting in the Luther Brook valley deposited the high gravel. These ice blocks may have been contemporaneous with the highest level (335 m) of Glacial Lake Lobster in the Penobscot Valley. Rhythmically bedded sands and silts (examined at stops 8 & 9) were deposited into Glacial Lake Lobster and a subsequent lower lake which measured 320 m a.s.l. (Glacial Lake Ragmuff I).

When the lake dropped to an elevation of 309 m (1020 ft), this flat landform built into Glacial Lake Ragmuff II. The following evidence suggests a erosional event in the Luther Creek basin: 1) the erosional contact on the top of the rhythmite section, 2) the lateral discontinuity of different rhythmite sections, 3) the rip-up clasts which underlie the foresets, 4) the limited thickness of foreset beds, and 5) the restricted extent of the deltaic deposits. We see the above evidence as indicating a flood event which eroded the former lake bottom in a local area and filled the eroded portions with sediment containing rip-up clasts then built a delta into shallow water (Stop 8, west section). In nearby areas where the erosion was not as great, gravel was deposited over or adjacent to eroded lacustrine beds (Stop 8, east section, and Stop 9).

This lowering of the lake level also eroded portions of the ice contact gravels in the Luther Brook valley and left only a thin cover of gravel over till at the apex of the gravel deposit. The entire landform including the high thin gravels, and both the lower erosional and depositional facies is mapped as a fan deposit with Luther Brook provided the water for the erosion of the rhythmite beds and the deposition of the deltaic sands and fan gravels.

59.9 Return to the Golden Road, turn left (W).

63.8 Pass mile 65 sign.

64.3 Turn left (S) toward Seboomook Dam.

67.2 Cross Seboomook Dam. End of Log. Return to Greenville by retracing first portion of road log to mile 11.6, turn left (S), continue straight through all intersections; about 20 miles to Rockwood. Turn left after crossing the Moose River, follow Rt. 6 and 15 to Greenville (1:15 total travel time).