

FIELD TRIP GUIDE
for the
FRIENDS OF THE PLEISTOCENE

30TH ANNUAL REUNION

MACHIAS, MAINE

MAY 20 - 21

1967

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LEADER

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INTRODUCTION

In 1935, Leavitt and Perkins briefly and superficially dealt with the glacial geology of this area. Their map supplement shows, incompletely, the general distribution of the morainal complex.

During the summers of 1965 and 1966 I spent six months in field mapping and studying this end moraine complex which generally parallels the coast with the support of two research grants from the National Science Foundation.

I have traced the complex from Eastport to Waldoboro, a distance of about 150 miles. It appears that the complex probably continues further to the southwest into the Portland region and may include the frontal deposits of the Kennebunk advance described by A. L. Bloom (1960).

Reconnaissance has shown that the complex continues, discontinuously northeastward from Eastport, at least to the area of St. John, New Brunswick.

In eastern coastal Maine the width of the complex varies between 10 and 30 miles. To the south, the distal side of the complex, the moraines stand in the sea, and to the north they pass abruptly into extensive stagnant-ice deposits.

The complex is composed of a series of broadly lobate, cross-cutting end moraines, relatively small areas of "washboard" moraines, interlobate deposits, inice marginal kames and ice-contact, outwash marine deltas.

Individual moraine segments are commonly one to three miles long, but occasionally are much longer. Their widths vary between 100 and 400 feet and they are up to 50 feet in relief.

Their internal composition is variable. Some segments are composed of compact clay and silt-rich till. However, the majority seem to be combinations of ice-contact stratified drift with lesser amounts of till.

In the few extensive exposures, deformation and till fabric are related to thrusting of the ice margin during the accumulation of the moraines.

The moraines were constructed at the margin of an active ice sheet that was undergoing thinning and fluctuating marginal retreat. This is indicated by the deformation within the moraines, their cross-cutting lobate pattern, the interlobate deposits of till and ice-contact stratified drift located upon or directly in front of bed rock highs and the several areas of small washboard moraines in topographic lows.

The large volumes and wide distribution of ice contact stratified drift in the moraines indicate that extensive melting of the ice sheet was prevalent and that meltwater was discharging all along the ice margin. Occasionally, localized drainage from the ice deposited large masses of stratified drift with kame-like form at the ice margin. These deposits, such as those that comprise Carr and Gilman Hills, each with a relief of approximately 200 feet, may have been built as alluvial cones or possibly deltas against the ice margin.

This complex of marginal features represents a hesitation during the dissipation of the ice sheet whose outermost margin stood seaward of the present coast. There is no evidence indicating any significant time separation between advances of the various lobes represented in the morainal complex.

By the time the ice margin had retreated to the proximal edge of the present morainal complex, the ice ceased to move internally and thereafter dissipated by separation and stagnation immediately to the north.

At times during the construction of the morainal complex, sections of the retreating margin stood in the sea as evidenced by (1) a few extensive, ice-contact glaciomoraine deltas, such as at Pineo Ridge, near the proximal edge of the complex, (2) a lobate pattern of some moraines, especially those close to the present shore that roughly parallel the contours, sug-

gesting that the configuration of the ice margin was at times controlled by the sea, and (3) the absence of valley trains.

The late-glacial sea ultimately rose to an altitude of approximately 260 feet. At that time extensive ice-contact marine deltas were built when the ice margin had retreated to what is now the proximal edge of the morainal complex.

Thereafter, the sea dropped to an altitude of approximately 240 feet where it cut a prominent cliff and bench into the delta face. A few abandoned meltwater channels leading from large kettle holes in the delta, and cutting through the marine cut cliff and across the marine-cut bench attest to the presence of ice masses during the early stages of regional emergence.

This emerged shoreline at 240 feet can be traced, discontinuously, for over 100 miles. No evidence for a still stand of the sea was found below this level.

Radiocarbon dates derived from shells in the marine clay overlying the moraines in the immediate coastal area indicate that the moraines formed prior to 12,400 years ago. However, a regional evaluation of the time of the marine submergence of the area by Stuiver and Borns (1967) show that the moraines probably formed about 12,600 to 12,800 years ago.

STOP 0: BLUEBIRD MOTEL PARKING LOT, FIRST DAY. Buses leave at 8 a. m.

Our first day will be spent in the Columbia Falls-Cherryfield quadrangles, west of Machias.

EN ROUTE TO STOP 1:

(12 miles)

Turning left on Route 1 the buses travel toward Jonesboro. After 2 miles we drive onto an end moraine and follow its crest for about 3 miles. The lack of trees in this area is the result of an extensive forest fire several years ago. At the intersection of Routes 1 and 1A, we turn (S) off the distal side of the end moraine, following Route 1 for 2.5 miles to the Grange Hall in Jonesboro. Across from the Grange Hall we turn right (NW) towards Jonesboro Station. In 0.4 miles, note the kame on the left.

At Jonesboro Station we drive onto an end moraine and ride along its crest for about 0.5 miles before turning off its proximal side. The continuation of this moraine is buried by the Columbia Falls delta as you can see just ahead.

We are now traveling across a wave-cut bench and approaching a wave-cut cliff.

STOP 1: COLUMBIA FALLS DELTA

(15 minutes)

We are standing on a wave-cut bench incised into the face of the Columbia Falls delta.

Just to the north you can see the wave-cut cliff whose base is at an altitude of 240 feet. Note that the moraine we have been traveling on from Jonesboro Station has been included in the benching. Its position is indicated by a lag concentrate of boulders.

EN ROUTE TO STOP 2:

(2.25 miles)

Continuing northward we climb the wave-cut cliff onto the kettled

delta top at an altitude of approximately 250 feet. In 0.4 miles we descend the ice-contact slope and continue northward for 1.5 miles. We are now climbing the SE slope of a kame. We turn sharply left and travel on the crest of the kame for 0.2 miles.

STOP 2:

(30 minutes)

This is one of four kames extending in a line from the ice-contact side of the Columbia Falls delta, about 1 mile to the south, to Milton Mountain, a bedrock hill, about 2 miles to the north. These deposits of ice-contact stratified drift mark the course of a former meltwater drainage way in the ice. Where the drainage reached the glacier margin, which was in the sea, the Columbia Falls delta was constructed. Hereafter in this paper the intersection of a wave-cut bench and cliff will be called the nick point.

This kame has a prominent nick point on the SE and SW facing slopes at an altitude of 240 feet. There is no evidence that the sea stood any higher than this level. However, there are several lower, less pronounced nick points on this kame as well.

The other three kames were likewise nicked, but far less conspicuously. The boggy lowlands that you see to the east and west are underlain with marine silt and clay, presumably the Presumpscot Formation of A. L. Bloom (1960).

EN ROUTE TO STOP 3:

(1.5 miles)

As we travel south off the kame and along the east slope of the next kame note the kettle holes below the altitude of 240 feet. Their "sharpness" implies that they developed after the sea dropped below the lowest level of their rims.

As we round the kame and travel up onto the proximal side of the delta you can see the irregular ice-contact topography to your left and right. Note the kettled surface of the delta. We are now descending the

distal side of the delta and will turn right into a gravel pit at the base of the slope.

STOPS 3 AND 4:

(20 minute discussion at Stop 3: a 10 minute walk to and a 15 minute discussion at Stop 4. Total time is 45 minutes.)

Stop 3. This pit, developed in the delta's edge, is the only adequate exposure of the internal structure of the delta and, at that, only topset and foreset beds can be seen.

Figure 1 will show you that a moraine forms part of the proximal edge of the delta, indicating that the delta prograded into the sea from the ice margin. In prograding the sediments buried segments of older moraines.

The walk to Stop 4 will give you the opportunity to observe the delta's top. Note that its surface at an altitude of about 255 feet in this area is broadly basined and that distributary channels have not been preserved.

Stop 4. We are standing on the depositional surface of the delta looking down upon the highest wave-cut bench cut into the delta face. The bench and associated wave-cut cliff are traceable continuously around the distal edge of the delta to the area of Stop 1, 1.5 miles to the east. The nick point is at an altitude of 240 feet.

The formation of the large kettle hole before us has involved portions of the nick point, indicating that sealevel had fallen below the 240 foot altitude while some buried ice still remained in the delta.

The various features seen and discussed at Stops 1, 2, 3, and 4 suggest the following sequence of events for the area of the Columbia Falls delta.

As the margin of the internally active ice retreated, it stood in the sea. Sewall Ridge and Milton Mountain progressively exerted more positive topographic control on the thinning ice causing it to develop two lobes. The interlobate area became the locus for southward meltwater drainage and collection of glaciofluvial sediments. When the ice dissipated these sediments were deposited as a string of connected kames between Milton Mountain and the proximal side of the delta.

The meltwater stream disgorged water and sediments into the sea at the ice margin constructing the delta around and/or over ice blocks (?).

As the ice margin retreated, the building of the delta ceased and its surface became emergent. Following the emergence a temporary balance was achieved between the rates of land and sea rise which resulted in the development of the prominent nick point at the 240 foot altitude. The presence of the nick point at the same altitude on the kames behind the delta indicates that the ice margin retreated northward at least to Milton Mountain just after the delta surface had emerged about 15 feet.

The persistence of the nick point at an altitude of 240 feet along the south face of the delta argues that most of the ice in the delta had dissipated and that the resulting adjustments of the deltaic sediments were completed before the nick point was cut by the sea.

The sediment eroded by the sea from the west and south margins of the delta was transported to its eastern end deposited as a spit.

Several less prominent nick points can be detected on the delta face at altitudes lower than 240 feet.

EN ROUTE TO STOP 5:

(2.5 miles)

We are now traveling southwestward toward Columbia Falls along the wave-eroded crest of a moraine. This moraine is probably the westward continuation of the Jonesboro Station moraine which we saw on the east side of the delta (see Figure 1).

In 0.5 miles the moraine swings westward. We travel down its distal side and cross over several small end moraines veneered with marine clay before reaching Columbia Falls R. R. Station.

A sharp left turn and then a sharp right turn puts us on Route 1 traveling westward. (The construction of Route 1 postdates the publication of both the Columbia Falls and the Cherryfield quadrangle maps.) After crossing the Pleasant River we ascend the east-facing valley slope and stop at the top of the hill.

STOP 5:

(15 minutes)

Route 1 cuts through two end moraines at this location (see Fig. 1). The morainal ridges, continuous for about 2 miles, trend NW-SE with their proximal sides facing NE. These moraines mark a former position, perhaps terminal, of the western margin of an ice lobe which predates the Columbia Falls delta.

EN ROUTE TO STOP 6:

(13.5 miles)

Continuing on Route 1 southwestward for 10 miles through Harrington we travel to Cherryfield across a lowland veneered with marine clay. In this 10 miles we have crossed at least 50 temporary recessional ice margin positions of an ice lobe that advanced from the NW. Figure 1 shows a few of the more prominent end moraine segments marking some of these margin positions.

At Cherryfield, the Blueberry Capital of Maine, we cross over the Narraguagus River. This is one of the few remaining Atlantic Salmon fishing rivers in the northeast - see them jump! In 0.25 miles we turn right onto Route 182 following it northwestward across two morainal ridges mantled with marine clay. In about 1 mile, we turn right and continuing on we bear right again in 0.75 miles. In another 0.75 miles we arrive at Stop 6.

STOP 6:

(30 minutes)

This blueberry barren which we are about to ascend belongs to Mr. Farren. He has graciously consented to allow us access to his property providing we do not walk on the new blueberry bushes.

PLEASE STAY ON THE PATHS

This stop will provide the opportunity for you to observe the morphology of a typical small end moraine which extends westward connecting the south end of Burke Hill with the unnamed hill 1 mile to the west.

I am especially interested in any opinions concerning the origin of the moraine-like deposit that conforms to the southern margin of Burke Hill. I'm baffled.

EN ROUTE TO STOP 7:

(5.5 miles)

We are retracing our route to Cherryfield. Turn left on the River Road just after crossing the Narraguagus River and travel northward for

1 mile past the Wyman and Stewart Blueberry Packing Companies on the left. In 0.5 miles we climb the distal side of a very prominent end moraine (it is clearly seen on the left). On its crest turn right on a road appropriately named Ridge Road.

STOP 7:

(15 minutes)

At this location the Ridge Road moraine wraps around the NW side of a large bedrock knob.

The reason for this stop is to give you a panoramic view of a few of the many, many small, boulder strewn, recessional end moraines to the northwest. These moraines commonly form groups of "classical" washboard moraines.

The ice lobe responsible for these moraines advanced from the NW across at least 25 miles of this quadrangle (see Fig. 1). Large kames associated with the recession of this lobe exhibit well-developed erosional shorelines on all sides at altitudes of 260 feet and 240 feet as well as less prominent shorelines at lower elevations.

This and other evidence indicates that the recession of this lobe predated the construction of the Columbia Falls delta.

On the skyline to the north you can see the front slope of the Pineo Ridge delta extending for at least 10 miles from left to right.

EN ROUTE TO STOP 8:

(4.0 miles)

We continue northward along Ridge Road for about 2 miles. Now we are climbing the front slope of the Pineo Ridge delta. Note the fine deltaic sand in the road cuts. The low areas immediately south of here are veneered with marine clay.

At the intersection on the top of the slope we bear left and continue north across the surface of the delta.

Here the depositional surface of the delta is at an altitude of 260 feet and it gradually rises to about 270 feet to the edge of the moraine at the northern edge of the delta.

As we continue, notice abandoned distributary channels on either side of the road. Many of these can be traced into ice-contact heads at the north edge of the delta. By looking at the shallow road cuts you can also get the impression that the sedimentary character of the surface changes from fine to coarse grain as we travel northward.

In about 0.75 miles the first kettle holes appear in the surface. These increase both in number and in size as we travel on.

STOP 8:

(1 hour for lunch and 30 minutes for discussion)

We are now standing on the end moraine which, at this location, marks the proximal side of this ice-contact, outwash, marine delta.

This moraine and associated delta mark the terminal position of the last ice advance in the region. This lobe advanced from the north and crosscut the deposits of the earlier advances from the north and northwest (see Fig. 1).

All along the distal margin of the delta one can find end moraines deposited by earlier lobes, especially those of the lobe that last advanced from the NW, which have been buried to varying degrees by the prograding delta. This burial indicates, along with other evidence, a time separation between the ice advance from the NW and that from the N which left the Pineo Ridge moraine and delta. This time separation was at least long enough to allow for the dissipation of the portion of the ice lobe within the Cherryfield quadrangle, which advanced from the NW.

EN ROUTE TO STOP 9:

(1 mile)

We are retracing our path southward part way across the delta surface.

STOP 9:

(10 minutes)

We are standing approximately in the center of the U. S. Coast and Geodetic Survey Base Line upon which all mapping control in Maine is based.

The line, trending N73°W is 5.3 miles long, was surveyed during the first half of the 19th century. Jefferson Davis, later to become President of the Confederate States of America, participated in the establishment of this line.

As you look around at this location, and in other areas we've been in today, I'm sure you've noticed the vast areas under blueberry cultivation.

In 1958 Maine produced 85% of the world's blueberries. Today Maine produces only 30% of the world's supply. Of the 100,000 acres of land in Maine presently under cultivation 50,000 acres are in this area.

EN ROUTE TO STOP 10:

(2 miles)

Continuing south for another 0.7 miles we turn left just before reaching the front slope of the delta and continue eastward for 1.3 miles.

In the first 0.5 miles, after turning east, note that we are passing over many bouldery ridges with N-S trends. These are small remnants of recessional end moraines associated with the ice lobe that advanced from the NW. Here, the moraines are partly buried by the younger delta sediments (see Fig. 1).

These moraines have been segmented by meltwater streams and perhaps by marine action prior to burial by the prograding delta.

STOP 10:

(45 minutes)

Note the characteristics of the valley to your right as we walk the 0.2 miles south to the distal edge of the delta.

Here we are standing on the depositional surface of the delta at an altitude of 260 feet. As the constructional phase of the delta came to a close the delta emerged about 20 feet and the sea eroded a prominent bench and cliff with the nick point at an altitude of 240 feet. This highest recognizable nick point is present along about 90% of the length of the delta front and is at the same altitude as the uppermost nick point on the Columbia Falls delta. After this nick point was formed the delta emerged

rapidly and several lower, less conspicuous, nick points were developed (see Fig. 2).

The question now arises: was glacial ice present in the area as the delta emerged? The following line of reasoning suggests that it was. The "dry" valley that we observed on the walk in, heads upstream in ice-contact stratified drift. It appears that the meltwater was still flowing southward as this section of the delta emerged. The abandoned meltwater channel continues from the depositional surface down the distal slope of the delta where it has been deeply incised into the wave-cut cliffs and benches.

This stream continued to flow until sealevel had lowered, relatively, at least to the present 200 foot altitude. The earlier and smaller channel at this location was abandoned when the sealevel stood at the present altitude of 210 feet.

The continuity of the nick point at the altitude of 240 feet along the south face of the delta argues that the ice margin, at the proximal side of the delta, had extensively dissipated and was no longer contributing meltwater and sediments in sufficient quantities to allow the delta to maintain its prograding regimen by the time that the nick point was cut at the 240 foot altitude. However, the analysis of the stream valley at this location and at as many as ten other locations along the delta margin indicates that some glacial ice still remained at a time when emergence was well under way. This conclusion is supported by the observation at Stop 4. One may suggest that the deeply incised valley here, at Stop 10, location was not made by meltwater from glacial ice, but from more recent runoff from rain or melting snow.

Several observations argue against this: (1) no evidence for recent erosion, (2) the continuity of the valley with the meltwater channel on the delta surface, and (3) that the modern drainage activity is predominantly subsurface.

During the spring in particular, surface water sinks into the

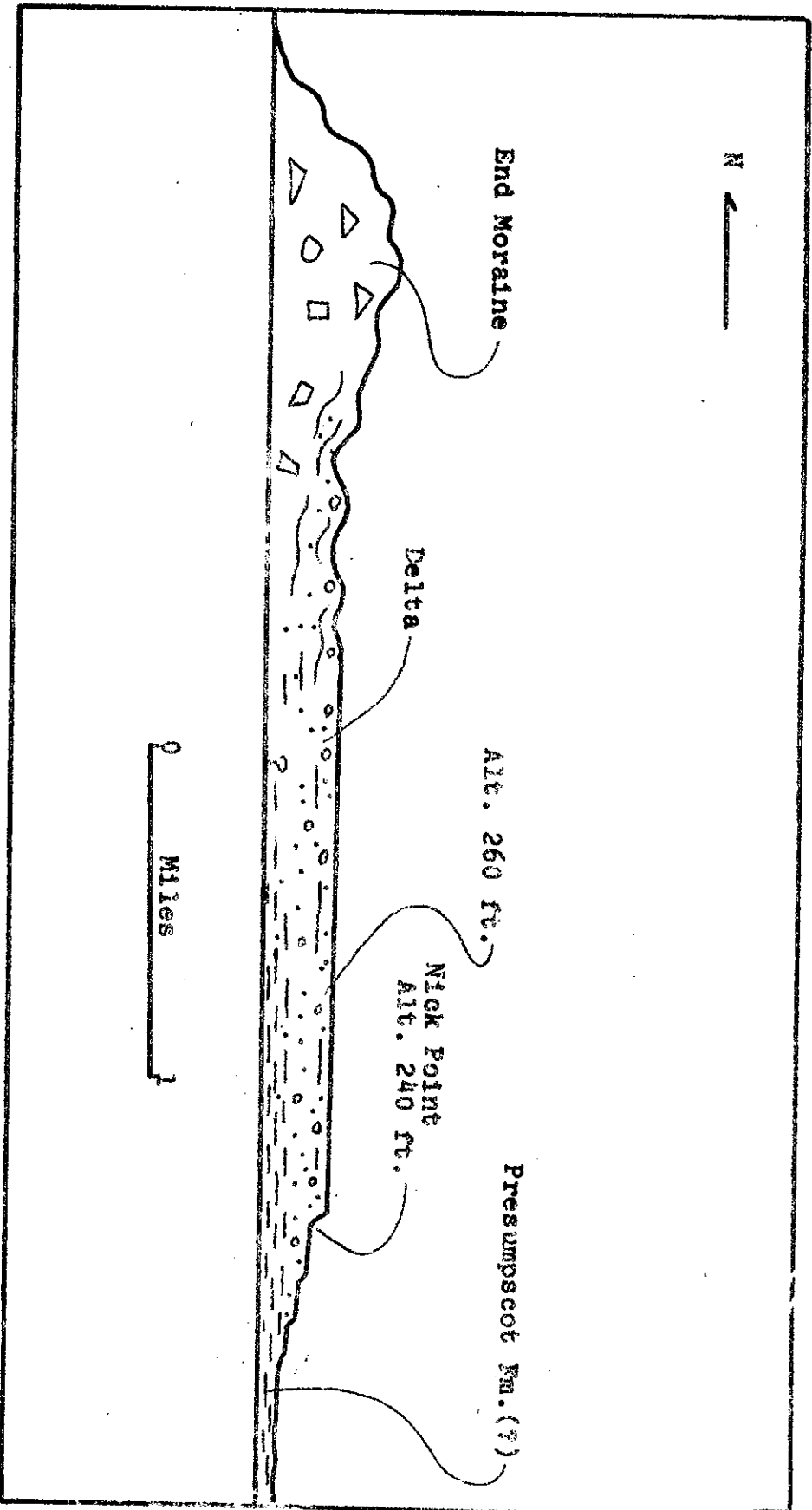


Figure 2. Schematic geologic cross section of the Pineo Ridge ice-contact marine delta.

permeable delta sediments until it reaches an impermeable zone and then exits as violently "boiling" springs at many locations along the base of the delta face.

At this location headward erosion by spring sapping can be demonstrated. Stone (1899) commented on the periodic, violent action of these springs. Auguring at this location has shown that within 15 feet of the bottom of the spring-sapped depression there is no sharply defined impermeable layer beneath gravel. However, the grain size becomes gradationally finer with depth until silt is predominant at a depth of about six feet.

This grain size distribution, coarse at the top becoming progressively finer with depth, is compatible with the interpretation that this is a delta.

EN ROUTE TO STOP 11:

(0.6 miles)

We continue eastward to the east end of the Base Line (called East Base on the Cherryfield map).

STOP 11: East Base

(15 minutes)

At this location we will walk from the delta surface for a way, down the stepped front slope to give you the opportunity to observe the marine features formed as the delta emerged.

EN ROUTE TO STOP 12:

(3 miles)

Continuing eastward for 0.5 miles note the two small bouldery end moraines on the right. These were buried by the prograding delta and later partially exhumed by marine erosion during emergence. These end moraines were constructed during the retreat of the ice lobe that advanced from the NW (see Fig. 1).

The road now passes on and off segments of end moraine and delta surface. These end moraine segments, trending E-W, mark the terminal position of the last ice that advanced from the north.

In 2.5 miles from Stop 11 turn right (south) at the crossroads.

STOP 12:

(15 minutes)

Examine Fig. 1 and you will see that at this location the E-W trending end moraine constructed by ice that advanced from the north crosscuts the N-S trending moraine of the ice that advanced earlier from the northwest.

We are at the intersection of these end moraines. The topography of the intersection suggests that the ice rode on to the older moraine and deposited its moraine without bulldozing the older moraine into an enlarged mass ahead of it. This type of overriding intersection is characteristic of all the intersections I have observed in the area. Why do you suppose this is so?

EN ROUTE TO STOP 13:

(8 miles)

Traveling south, we pass through the town of Columbia in about 1.3 miles (look quickly!). One mile further we turn left on Route 1 and follow it eastward across the end moraine at Stop 5 to Columbia Falls.

Continue on Route 1 for about 1.3 miles. Here we travel onto and along the crest of an end moraine for about 1.5 miles, then down into the valley of the Indian River.

0.5 miles east of the river turn left into the gravel pit on the west flank of Carr Hill. This pit is operated by the Maine State Highway Commission, but, along with the rest of Carr Hill, is owned by the University of Maine. The University uses the hill as an experimental blueberry research farm.

STOP 13:

(20 minutes)

Based on the exposures of stratified drift within this pit and upon the gross morphology of the hill, I have interpreted the deposit as a large kame.

The altitude of the hill top of 217 feet which is considerably lower than the tops of the Columbia Falls and Pineo Ridge deltas. Therefore, one would expect that the hill was submerged when the deltas were built. Truncation of strata and presence of a lag concentrate of cobbles and boulders at the top of the exposures in the pit probably resulted from marine action during the submergence.

Leavitt and Perkins (1930) were the first to suggest that both Carr Hill and Gilman Hill to the east, which we will cross on our return to Machias, were deposited as ice-marginal kames.

EN ROUTE TO STOP O:

(12 miles)

We leave the pit and turn left on Route 1 and travel east across the south-facing slope of Carr Hill. In 1.6 miles we travel up onto Gilman Hill, another kame, and along its crest for 1.8 miles. Between here and Jonesboro we travel on and through segments of end moraines which have a NE-SW trend. On Figure 1 note the relationship of these moraines to Gilman Hill. This relationship suggests that Gilman Hill was constructed at the ice margin, supporting the conclusion of Leavitt and Perkins (1930). Why didn't Gilman Hill become a delta?

We cross over the Chandler River into Jonesboro and then retrace our route of the morning to Stop O at the Bluebird Motel in Machias.

STOP O: Second day, Bluebird Motel parking lot. Buses leave at 8 a. m.

This morning will be spent examining the internal characteristics of two end moraines, the map pattern of the end moraines in general and their relationship to the marine clay. The purpose is to evaluate the mode, environment and time of their deposition.

EN ROUTE TO STOP 14:

(2 miles)

We leave the parking lot, turning right on Route 1. We travel for about 1 mile on a dissected marine-clay surface and then cross over two small, clay mantled, end moraines trending E-W. Continuing, we travel

on for 0.3 miles across the clay surface, up onto the proximal side of an end moraine and turn right into a "gravel" pit owned by Mr. Millard Whitney (see Fig. 1).

STOP 14:

(30 minutes)

The end moraines of this coastal belt display three different compositions:

1. all till, with a clay-rich matrix
2. all stratified drift
3. combination of till and stratified drift

At this location we see the third type in good exposure. The structures and fabrics in this pit indicate that the moraine was constructed by active ice flowing from about N15°W.

EN ROUTE TO STOP 15:

(17 miles)

Leaving the pit we turn left on Route 1 and continue through Machias. Just after leaving the center of town on Route 1 we cross over Middle River.

The first naval battle of the Revolutionary War was fought in Machias Bay. In May of 1775 Machias citizens captured the British Man-O-War, "Margaretta," and subsequently beached the vessel on the west shore of Middle River about 2 miles upstream from here. Presently the river is only about 5 feet wide and 2 feet deep at this location.

This shoaling as well as the shoaling of the Machias River estuary was due to the deposition of huge volumes of sawdust during the heyday of the lumbering industry in the 1850's. At this time Machias was one of the largest lumbering centers in the east.

After crossing the river we travel on a new section of Route 1 which postdates the publication of the Machias quadrangle map) towards East Machias. For the next mile we cross over several low NW-SE trending end moraines that have less than 10 feet of relief.

Just before entering the center of East Machias, we turn right on Route 191 towards Cutler.

In 0.6 miles as we head southeastward we pass through a valley-filling kame which has been partially excavated. This type of deposit is quite common in the narrower sections of the NW-SE trending valleys in the area.

In 1.25 miles and again at 1.75 miles we cross over two more such deposits. These are nothing more than end moraines composed of stratified drift.

We come to the shore of Holmes Bay in 0.5 miles. At this location we are traveling in the vale between two E-W trending end moraines (see Fig. 1). A sample of Portlandia glacialis (Gray) shells collected from eight feet below the surface from the marine clay in the vale yielded a radiocarbon age of $12,440 \pm 160$ years B.P. (Yale - unpublished). We then cross the southernmost of the two, travel about 0.25 miles before ascending another end moraine.

For the next 1.5 miles we are traveling along the crest of this moraine.

In this area, because of the hill that lies immediately northward of the moraine and 140 feet above it, an estimate can be made of the surface profile of the glacier, normal to the margin. This profile provides a convenient comparison with theoretical profiles as well as those measured on modern glaciers.

On the right, in another 0.3 miles, we pass Look's Seafood Cannery. The point of land you see to the east of the cannery is composed of marine clay resting against the distal flank of this end moraine along which we have been riding. A sample of Portlandia glacialis (Gray) shells from this location yielded a radiocarbon date of $12,200 \pm 80$ years (Yale - unpublished).

We are now traveling on the dissected surface of the marine clay and in 1.5 miles will pass the administration center for the Cutler Naval

Radio Station on the right. We continue toward North Cutler, a distance of 2.7 miles, on a veneer of marine clay whose continuity is interrupted occasionally by mounds of stratified drift protruding through it. These mounds are kames which probably formed at the ice margin.

Just before the next intersection we travel up the proximal slope of a large end moraine and on the crest follow Route 191 to the left. Continue for 0.6 miles to Stop 15.

STOP 15:

(60 minutes)

This E-W trending end moraine is one of the most prominent and accessible in the area. It is traceable, as a nearly continuous ridge, for 10 miles (see Fig. 1).

In their study of the glacial geology of Maine, Leavitt and Perkins (1935) reported briefly on some of the end moraines in this region. This particular end moraine is the only one of this complex that they placed on their surficial geological map of the state. Their description of this end moraine is as follows:

"The frontal deposits (in Maine in general, and at Cutler in particular) take on the form of a rather smooth or hummocky ridge, with an ice-contact slope on the proximal side and a gently sloping wash plain on the distal side. Goldthwait has termed frontal deposits of this type moraine banks."

"Moraine banks" were visualized as forming along an ice margin which was standing in shallow water.

The orientation of the shoreline exposures at this location provide an opportunity to study the internal construction of the moraine. Unfortunately, very few exposures like this are available.

After this exposure has been examined we will discuss, with the aid of Fig. 1, the relationship between the ice margin and the sea at the time that the moraines were deposited.

EN ROUTE TO STOP 16:

(0.7 miles)

We leave the "gravel" pit, turn right (west) on Route 191 and travel along the crest of the end moraine again. In 0.6 miles we continue straight where Route 191 turns right and stop in about 0.1 mile.

STOP 16:

(5 minutes)

In February of this year the Maine State Highway Commission bored a hole for me at this location to a depth of 45 feet where practical refusal was reached. This refusal does not necessarily mean that bedrock was reached. At the 45 foot depth about 900 hammer blows were required to drive the casing one foot.

Analysis of the bore hold samples indicates that the end moraine, at this location, is primarily composed of stratified sand and coarse gravel. Interbedded with this are layers of clayey "till" ranging from 1 to 4 feet in thickness, and occasional clay layers about 1 to 2 feet thick.

EN ROUTE TO STOP 17:

(1.5 miles)

We continue westward along the crest of the end moraine for about 1 mile to the gate into the VLF antenna field area of the Cutler Naval Radio Station. This is restricted area. However, Lt. W.R. Bruns, Executive Officer of the station, has given us permission to visit pits along the crest of the end moraine this morning.

Continuing through the gate for 0.5 miles we turn right into a pit developed in the end moraine.

STOP 17:

(30 minutes)

With the exposures here you can develop a stratigraphic cross section of this end moraine and in doing so you become aware that the moraine owes its surface configuration to (1) glacial deposition and (2) to modifications accomplished by the sea during submergence and ultimate emergence (see Fig. 3).

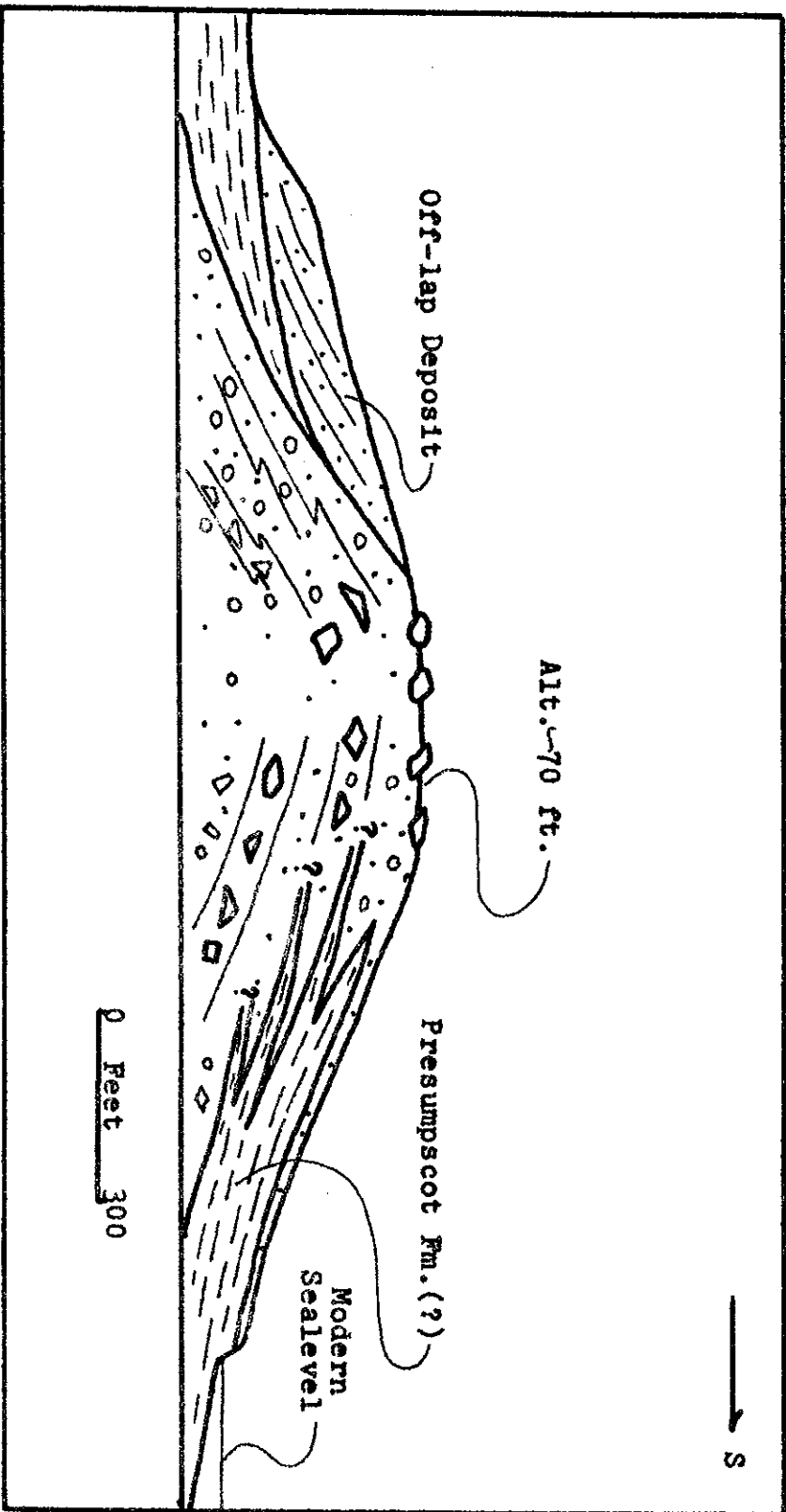


Figure 3. Geologic cross section of the end moraine at North Cutler.

A sample of shells and seaweed was collected near the base of the clay where it rests upon the proximal slope of this end moraine at its western end (Sprague Neck).

The shells and seaweed were separated and dated independently. They yielded the following radiocarbon dates (Yale - unpublished).

<u>Mytilus edulis</u>	11,920 \pm 120 years B. P.
seaweed	11,880 \pm 250 years B. P.

Presumably these indicate the time when, after the ice margin had retreated, the transgressing sea started to rise against the proximal side of the end moraine. At this time we can devote some time to a discussion of the age of the end moraines in this coastal morainal complex.

EN ROUTE TO STOP O:

(18 miles)

We will now retrace our route to the Bluebird Motel.

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