TRIP F: THE PLEISTOCENE GEOLOGY OF THE MONTAUK PENINSULA

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INTRODUCTION

Long Island is a long narrow island reaching east-northeastward from New York City to form a "fish-like" extension of New York State. The island lies south of and is approximately parallel to the Connecticut shore of New England and is separated from it by Long Island Sound. Long Island forms the north shore of an Atlantic Ocean reentrant known as the "New York Bight".

Although part of the Coastal Plain Physiographic Province, Long Island features a topography almost completely modified by glacial and proglacial processes. Two conspicuous end moraines extend from west to east along the axis of the island. The older Ronkonkoma moraine, probably Wisconsin in age, makes up a major portion of the Montauk Peninsula. The younger Harbor Hill moraine generally follows close to the north shore of Long Island east to Orient Point. The island abounds in other glacial and proglacial features such as the coalescing outwash fans and aprons which form much of the southern portion of the island.

THE MONTAUK PENINSULA

The Montauk Peninsula, as here defined, extends east from the village of Easthampton to Montauk Point. Montauk Point is the eastern extremity of the Ronkonkoma Moraine which forms a ridge of coalescing hills travesing the area from west to east. It marks the maximum advance of an ice sheet during late Pleistocene time. East of Montauk village, the moraine appears to be composed principally of till but does include glaciofluvial material. Further to the west, the moraine contains increasing amounts of stratified drift. East of Montauk village, the moraine abuts the shoreline; however, west of this village the southern border of the moraine is found at an increasing distance from the south shore, from which it is separated by littoral and aeolian deposits. In the vicinity of Easthampton village, outwash is encountered in a limited area between the moraine and the south coast (Figure 1).

Much of the Montauk Peninsula is characterized by knob-and-kettle topography ranging in altitude from sea level to about 200 feet above sea level. However, the glacial drift has been extensively modified by littoral and aeolian processes. East of Montauk village, steep wave-cut bluffs rise abruptly from 30 to 80 feet above narrow boulder-strewn beaches. Fronting the ocean, from the village westward, are increasingly wide sandy beaches, backed from Hither Hills west, by extensive beach ridges. Littoral spits, bay-mouth beaches, and tombolos are common, especially along the north shore. Coastal sand dunes which have migrated inland for distances of up to 1.5 miles, cover most of the area behind the south-shore beaches from Hither Hills west to Easthampton.

PLEISTOCENE STRATIGRAPHY

As summarized by Muller (1965), the Long Island sequence of glaciation was inferred by Fuller (1914) to commence with the deposition of the Manetto Gravel which Fuller interpreted as glaciofluvial in origin because of the relatively abundant granite pebbles and the occasional boulders up to two feet in diameter. The younger Jameco Gravel evidently is stratified drift, perhaps Illinoian in age. The fossiliferous (marine and lagoonal flora and fauna) Gardiners Clay is found at depths of fifty or more feet below sea level under the south shore of Long Island and is undoubtedly interglacial, quite possibly Sangamon in age.

Fuller considered the Manhasset Formation, including both the glaciofluvial (Herod and Hempstead Gravels) and glacial (Montauk Till) units, pre-Wisconsin in age. MacClintock and Richard (1936) questioned the validity of distinguishing the Montauk Till as a unit separate from the younger Ronkonkoma and Harbor Hill Tills. Locally, the Jacob Sand, presumably of marine origin and post-Gardiners but pre-Manhasset in age, is exposed. The environmental significance and even the uniqueness of the Jacob Sand remains poorly defined.

We find that Fuller's (1914) mapping and description of eastern Long Island's Pleistocene terrane is largely unassailable although his interpretation of the areal geologic history requires extensive revision.

The Gardiners Clay Problem.

"The Gardiners Clay derives its name from Gardiners Island ... on which several clay beds with included sands are well exposed at a number of points" (Fuller, 1914, p. 92). Fuller specifically restricted the term to interglacial clays. On western Long Island, the Gardiners Clay is consistently encountered under the south coast at depths of fifty or more feet below sea level. It yields marine and brackish water fossils similar to forms presently living along the Long Island littoral. According to Fuller (1914, p. 105-106), two localities on Gardiners Island contained fossils: (1) a locality just east of Cherry Hill Point, and (2) another unspecified locality. MacClintock and Richards (1936) visited the Cherry Hill Point locality and confirmed the presence of an interglacial fauna. However, Suter et al. (1949) although confirming the previous finding by MacClintock and Richards, found that the Gardiners Clay on Gardiners Island is, in large part, varved and, therefore, probably lacustrine in origin. Upson (1966) reported that many of the silt and clay exposures along the eastern portion of the north shore of Long Island are lacustrine rather than marine in origin and believes they are glacial rather than interglacial in age.

We sampled the "Gardiners Clay" at Montauk Point (STOP 1) and examined it for Foraminifera, diatoms, spores and pollen. Most samples were devoid of microfossils. However, several samples contained lean assemblages of cool Pleistocene flora including Pinus (pine), Picea (spruce) and Betula (birch) as well as reworked Cretaceous and Tertiary spores and pollen. The paucity of pollen grains suggest they were transported into the depositional site by both wind and glacial meltwaters. Certainly, the lack of marine microfossils and the cool Pleistocene flora suggests that the "Gardiners Clay" represents a diachronous diversity of depositional environments.

The Montauk Till Problem.

In his attempt to fit Long Island stratigraphy into the classical four-fold divisions of the American mid-west, Fuller catalogued the Montauk Till as Illinoian in age. The inadequacy of Fuller's assignment has long since been corrected by MacClintock and Richards (1936). Nevertheless, the distinctive banding or lamination and compactness of the Montauk Till in its type area near Montauk Point (STOP 1) led both Woodworth and Wigglesworth (1934) and Kaye (1964) to correlate tills of similar aspect which they encountered on Martha's Vineyard with the Montauk Till of Long Island. Furthermore, they considered all these tills as Illinoian in age. We believe that till fabric, aspect, structure and stratification are an unsatisfactory basis for correlation. The intimate relationship of the Montauk Till with the Ronkonkoma Moraine indicates they are the stratigraphic and morphological representatives of a single glacial stade and are probably Wisconsin in age.

Laminated Silt.

Upson (1966) believes that the deposits identified by Fuller as Gardiners Clay in eastern Long Island were locally deposited in shallow depressions on till and outwash from the glacier which deposited the Montauk Till. Upson suggested that these deposits, previously called Gardiners Clay, are of limited extent and do not underlie any appreciable part of Long Island. These deposits are probably ice-margin lacustrine deposits and are not the same as the marine and brackish water clays found at depths of 50 or more feet below sea level in western Long Island which Fuller also included in the Gardiners Clay.

These laminated sands, silts and clays are well-exposed at and near Montauk Point (STOPS 1 and 2) and our preliminary examinations support Upson's contention. The laminated deposits at Montauk Point contain varying proportions of Cretaceous and Tertiary as well as Pleistocene pollen and spores. The occurrence of rebedded pre-Quaternary pollen and spores in the region is by no means unique. Davis (1961) found that varved clay from Taunton, in southeastern Massachusetts, yielded Tertiary and Cretaceous pollen as did Groot and Groot (1964) in boring samples from the Texas Tower sites off New England. Sparse local vegetation and readily dispersed pollen from distant sources apparently made limited contributions to these ice-margin environments as did rebedded older pollen and spores. These data suggest that the periglacial landscape was nearly devoid of vegetation and that the tundra and boreal vegetation seres developed at some subsequent time (see Davis, 1965, 1967; and Sirkin, 1967) for further discussion of the late-glacial "tundra" problem).

Loess

Fuller (1914, p. 166-167) noted that "Certain parts of the outwash plain have a thin superficial coating of dark-brownish loam, consisting in some places largely of sand, but in others of pebbles intermixed with a certain amount of finer silt. It is this finer material, which is oxidized, that gives the color to the deposits. The depth is in some places only a few inches and was nowhere seen to exceed 1 1/2 feet. No trace of lamination was noted in the deposits seen by the writer".

We find that most of the glacial drift on the Montauk Peninsula is blanketed by up to 10 feet of sandy silt. Furthermore, these silt deposits usually lie on a lag gravel concentrate which occasionally yield ventifacts and, rarely, dreikanters. Schafer and Hartshorn (1965) report that a similar mantle of aeolian material is nearly ubiquitous in much of southeastern New England. They suggest that the loess was derived mostly from areas of stratified drift during deglaciation before the surface was covered by vegetation. To our knowledge, loess has not previously been reported from Long Island.

HOLOCENE SHORELINE MODIFICATION

The shoreline configuration of the Montauk Peninsula has undergone significant change in Holocene times. Taney (1961) and Krinsley et al., (1964) noted that the headlands of the Montauk Peninsula have been eroded and truncated by wave and littoral processes and the sediments so derived have generally moved towards the west. As the littoral sand moved westward, a narrow beach formed, abutting the headlands and sealing up small bays from the sea. The peninsula, which once extended for several miles to the south and east, has, owing to its exposure to the open sea, eroded back to its present location.

The Flandrian Transgression drowned swales in the Ronkonkoma Moraine separating portions of the peninsula into a series of islands in mid-Holocene time, some 2000 to 6000 years B. P. Presumably, Orient Point, Plum Island and the Gull Islands, off the north fluke of Long Island, (Figure 1) are a modern analogue of the ancestral Montauk Archipelago. Certainly, the Hither Hills area and the region east of Montauk village were islands separated from the Easthampton area. An additional strait may have trended north at Ditch Plains. Bluff erosion and longshore drift converted the archipelago into a peninsula by means of single and double tombolo construction during later Holocene time. The sequence and chronology of these events are still poorly known.

The conspicuous gap in the Ronkonkoma end moraine in the vicinity of Napeague Beach has been filled principally with sand derived from the high bluffs to the east (Taney, 1961; Krinsley et al., 1964). Indeed, that reach extending from Montauk village west to Easthampton village and including the Napeague Beach beach-dune tombolo complex is unique in that it appears to be the only portion of Long Island's south shore which is currently prograding (Taney, 1961). Initially, the later Holocene dominant mode of shoreline modification was erosional as witnessed by the prominent bluffs, now isolated from the south shore, at Hither Hills State Park and along Bluff Road (STOP 8). Debris, principally sand, derived from these bluffs was transported by long-shore drift constructing a spit towards the northeast, marked by the Promised Land Chenier, while another spit built west from Hither Hills west towards Southampton. This latter spit, roughly following the present right-of-way of Route 27, eventually connected with the Easthampton area in the vicinity of Bluff Road and formed the initial Napeague Beach tombolo. The spit prograded and sand derived from the early tombolo formed dunes which advanced towards the north, first shoaling and eventually filling the lagoon or bay north of the tombolo. The development of the tidal marsh sere undoubtedly accelerated the shoaling process, still going on in the vicinity of Napeague Harbor.

The aeolian process is distinctive on the Napeague tombolo. The dunes are, for the most part, active and obviously moving inland from littoral source area irrespective of the prevailing winds. The "walking dunes" on the east side of Napeague Harbor are especially conspicuous in that these dunes have both covered and extinguished a Quercus velutina (Black Oak) forest moving on towards the southeast to cover and kill additional portions of that forest while, at the same time, uncovering the now dead oak forest (STOP 7).

The south shore bluffs extending west from Montauk village to Hither Hills State Park erode only during times of exceptional storms such as the "Ash Wednesday" storm of March, 1962. Usually, these bluffs are separated from the shore by fringing beach and incipient dunes. The distinction of shoreline as contraposed to coastline is well defined along this coastal reach.

ABSOLUTE CHRONOLOGY

At the time of manuscript submission, we possess no radiocarbon dates bearing on the timing of the events noted in this guide. Suitable material has been secured from several localities and submitted for radiocarbon dating. However, the required laboratory procedures have yet to be completed.

For the moment, we suspect that the gross Wisconsin chronology probably follows that depicted by Schafer and Hartshorn (1965) for southern New England. Analyses of cores from the Reeves Bay tidal marsh at the mouth of the Peconic River near Riverhead, some 30 miles west of Easthampton, suggest that area supported a spruce-pine forest ('A' Pollen Zone) some 11,000 years ago (Newman, 1966). Other radiocarbon dates from the Reeves Bay site indicate that sea level was some 8 feet below its present level some 4000 years B. P. and rose to within 4 feet of contemporary sea level about 1000 years ago (Newman, 1966; Redfield, 1967).

Messrs. Eugene Foord and William Parrott, seniors at Franklin and Marshall College, have collected wood splinters from boring samples penetrating the Smithtown Clay (Lubke, 1964). The Smithtown Clay unit, almost certainly a proglacial lacustrine deposit, underlies the Smithtown Basin in western Suffolk County and appears to be post-Ronkonkoma but pre-Harbor Hill in age. The small amounts of wood secured by Foord and Parrott have been submitted for radiocarbon dating and we hope the results will date what will come to be called the "Smithtown Interstade".

ROAD LOG

Assembly Point: Sheraton Tenney Hotel Parking Lot, Grand Central Parkway at LaGuardia Field.

Departure time. 7:00 a.m. All travel by bus!

Mileage.		
0.0	0.0	Southeast on Ditmars Blvd.
1.0	1.0	Turn right (south) onto 108th Street.
2.0	1.0	Turn left (east) and enter Long Island Expressway.
2.5	0.5	Flushing Meadow-the site of the two New York World's Fairs. The geology of this swale has been described by Newman (1966).
4.0	1.5	To your right (south) the campus of Queens College of the City University of New York.

8.0	4.0	Alley Creek Valley - a drowned and then partially filled embayment of Long Island Sound.
10.0	2.0	Lake Success on your right (south). The lake has an area of 60 acres, a maximum depth of 72 feet, no surface outlet, and is one of the larger kettles on Long Island. Note the (both) Ronkonkoma and Harbor Hill morainal topography.
21.8	11.8	Plainview(!)-Here we descend for a short distance from the Ronkonkoma moraine onto the outwash plain. Note the relief contrast.
26.7	4.9	After crossing West Hills, one of several central Long Island areas where pre-Pleistocene strata rise considerably above sea level and approach the surface, we descend to the Huntington Plain which may be the site of a proglacial lake overlain by a thin veneer of outwash (Lubke, 1964).
28.7	2.0	We rise again into the Half Hollow and Dix Hills, areas similar in structure to West Hills. The Ronkonkoma End Moraine lies on the north flanks of these hills.
35.5	6.8	Sunken Meadow-Sagtikos State Parkways. Here we descend once again for a short time onto the outwash plain. Pilgrim State Hospital forms the large building complex on the right (south). We then once again mount the Ronkonkoma moraine.
38.6	3.1	Veterans Memorial Highway exit off Long Island Expressway. Turn east-southeast onto Veterans Memorial Highway. We descend almost immediately from the Ronkonkoma Moraine onto the outwash plain. Note the distinctive "pine barrens" vegetation of scrub-oak and pine. This area is underlain by a podzol soil having a bleached lower "A" horizon. This area of Long Island is devoid of agricultural potential because the outwash lacks the loess cover which is conspicuous in farming areas on outwash further east.
46.4	7.8	Intersection of Veterans Memorial Highway and Sunrise Highway. Turn left onto Sunrise Highway. Town of Patchogue. Continue east through "pine barrens" on outwash plain.
64.9	18.5	Eastport: temporary terminus of Sunrise Highway. Northeast on Route 51. Note farming activity on outwash plain. The surficial loess makes the difference! Route 51 climbs onto the Ronkonkoma moraine and then descends towards Riverhead and the pitted outwash plain between the Ronkonkoma and Harbor Hill End Moraines.
72.0	7.1	Riverhead: at the Peconic River mouth. Traffic circle-right (east) on route 24.
75.0	3.0	Reeves Bay on left (north).

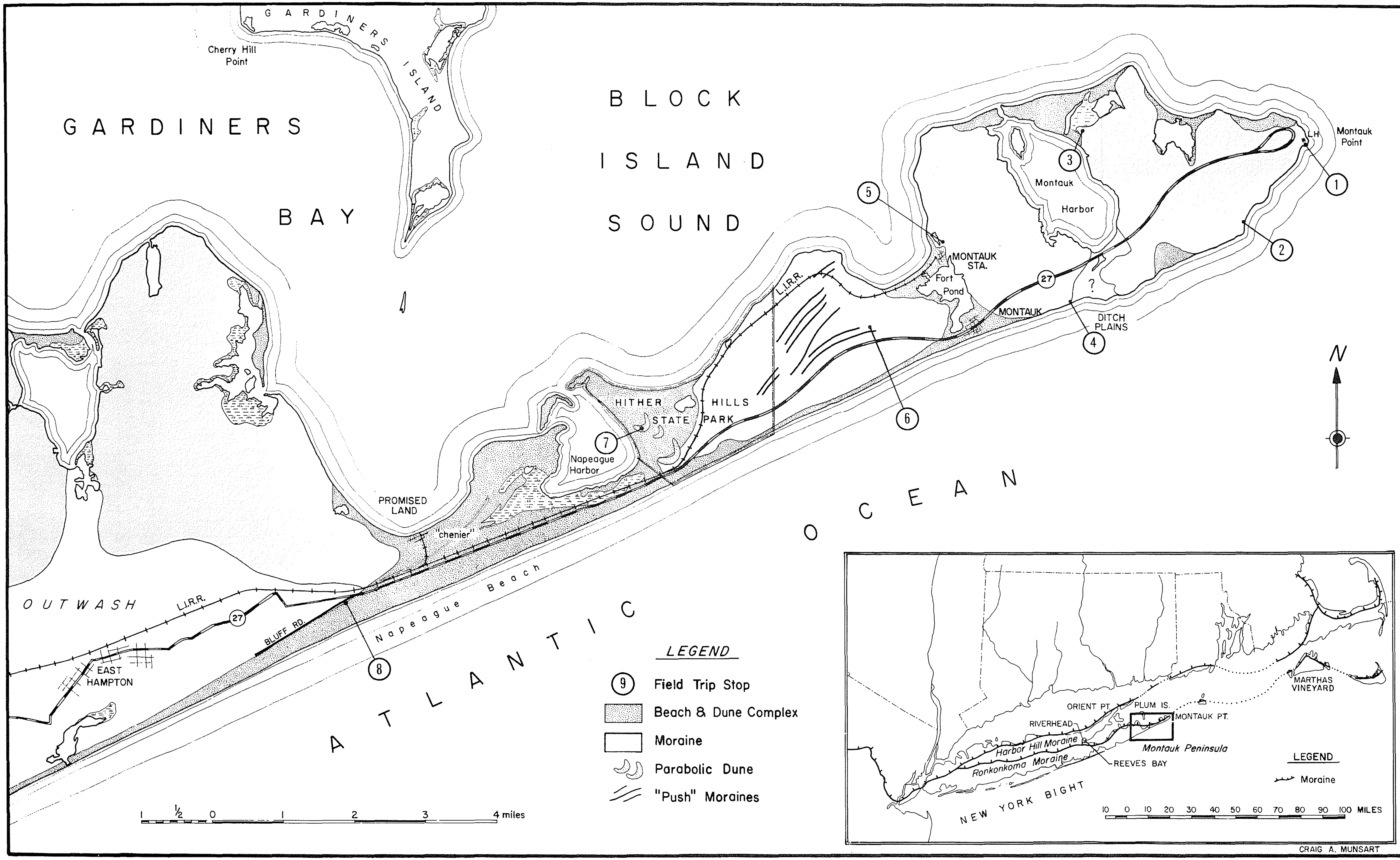

Figure 1. Outline map of the Montauk Peninsula. Inset map modified after Flint (1953).

79.0	4.0	Turn left (east onto route 27.
81.0	2.0	Cross Shinnecock Canal. We mount the Ronkonkoma Moraine once again.
99.0	18.0	Easthampton village.
99.3	0.3	Right turn at flagpole onto Dunemere Lane.
99.9	0.6	Dunemere Lane becomes Further Lane.
101.9	2.0	Right turn onto Indian Wells Highway.
102.2	0.3	Left turn onto Bluff Road. Bluff Road marks the crest of an abandoned wave-cut marine cliff cut into Ronkonkoma outwash. Progradation due to the construction of the Napeague Tombolo has separated the bluff from the sea for distances of up to 1.5 miles.
103.8	1.6	Half-right turn onto route 27. We descend from the bluff, now on our left onto the Napeague beach-and-dune-complex Tombolo.
109.0	5.2	Intersection of Old and New Montauk Highways. Note the abandoned wave-cut bluff on left as well as the dunes on glacial drift. Drive half-left onto the New Montauk Highway mounting the Ronkonkoma Moraine at Hither Hills.
114.6	5.6	The village of Montauk built, for the most part, on a double tombolo.
121.6	7.0	STOP 1. Montauk Point State Park, Montauk Point. 45 minutes. REST ROOMS ARE IMMEDIATELY ADJACENT TO THE PARKING LOT ENTRANCE.

Montauk Lighthouse was built in the years 1795-1797 about 300 feet from mean high water. It is now only about 60 feet from the water's edge. Following the field trip leaders, walk southeast crossing the road (WATCH OUT FOR TRAFFIC!) and follow the trail which commences at the lighthouse reservation entrance and skirts the south boundary down to the water's edge. To your left, towards the lighthouse is the section sketched by Fuller (1914, fig. 159, p. 144) which probably includes the type Montauk Till section. Starting from the base, Fuller identified the units in the bluff as "(a) Till phase of Montauk till member; (b) boulder pocket; (c) sand and clay phase of Montauk member; (d) clayey sand phase of Hempstead gravel member; (e) normal sandy phase of Hempstead gravel member". We interpret this section as consisting of Ronkonkoma (=Montauk) Till; a lag concentrate; laminated, probably lacustrine, silt, sand and clay; grading upwards into eolian silt and sand. Over towards the northeast, the section includes some stratified drift. The laminated unit appears to occupy a swale (kettle?) in the till. Listen (sic!) to the geomorphology and sedimentology. Returning to the busses, climb the bluff and look southwest. The bluffs are usually fringed by steep shingle-beaches and extend four miles southwestward to Ditch Plains.

Leave the parking lot and turn west on route 27.

122.6 1.0 Left turn into Montauk Air Force Station. Stop! We are now under military jurisdiction and supervision. Proceed under Air Force direction to south shore.

STOP 2. 1 hour. Leave the buses and enter upon the south shore beach. Immediately to the west is a mass of laminated silt and fine sand which Fuller considered "possibly" Gardiners. We believe this unit represents a proglacial lacustrine deposit. Walk southwest for 0.5 mile. Here we find the exciting section described by Perlmutter and DeLuca (1963). The major unit is the Montauk Till forming a 0.5 mile long open anticline. The Montauk Till overlies stratified drift consisting of interbedded gray and brown clay, laminated green and gray silt and clay, and some thin lenses of fine brown sand. Perlmutter and DeLuca found neither forams nor diatoms in the lower stratified drift which represents the oldest unit we will view on this trip. Immediately above the Montauk Till is stratified drift which ranges in thickness from a featheredge to about 30 feet and is composed chiefly of beds and lenses of brown and gray silt, fine to medium sand, and clayey sand. We interpret this unit as likely to be proglacial lacustrine in origin. Perlmutter and DeLuca report 5 to 20-foot-thick till unit on top of the upper stratified drift. However, Newman fails to note it. Occasional pockets of loess cap the section. Return to buses. Leave Montauk Air Force Station and turn left (west) onto Route 27.

124.6 2.0 Right turn (north) onto East Lake Drive. Note the morainal topography and surface erratics on right.

126.6 2.0 Right turn into borrow pit.

STOP 3. Montauk Airport Archeological Site. 30 minutes.

Geologically, this site includes a medley of till and ice-contact deposits including lenses of red-brown clay, silt and fine sand which Fuller would have referred to as Gardiners Clay. Overlying the drift is a lag concentrate, including occasional ventifacts, while the entire section is capped by loess. Pelecypod valves, including *Crassostrea virginica*, *Venus mercenaria* and *Pecten irradians*, form a "shell midden" associated with the upper portion of the loess blanket. The absence of artifacts suggests the midden dates from the "Archaic Stage" of aboriginal development and is thus some 4000 to 6000 years old. These aborigines probably harvested the lagoon or bay that existed immediately to the north of the site which has since been filled by the tidal marsh sere and then covered with sand dunes.

LUNCH STOP! Perhaps. It depends upon the wind direction. If conditions are unfavorable here, we'll eat at STOP 4.

Backtrack on East Lake Drive.

128.6 2.0 Intersection with Route 27. Right (west) on Route 27.

129.5 0.9 Left turn onto Ditch Plains Road.

129.9 0.4 Parking Lot behind south shore beach.

STOP 4. Ditch Plains Stratigraphic Section. 45 minutes.

Enter upon the beach and walk west 0.2 mile. At this point, the bluff presents a rather simple section consisting of the Montauk Till, a lag concentrate, with loess on top. However, further to the east, additional units are found beneath the loess. These new units of stratified drift appear to have an easterly dip component. At the east edge of the bluff, accentuated by a morphological reentrant at the back of the beach, the stratified drift clearly takes on the aspect of a delta built into a standing body of water. However, this critical exposure is frequently obscured by slump from the still younger unit, aeolian sand comprising dunes, found above the loess. At about this point, the Montauk Till surface dips below the beach and two additional units are found which outcrop near the upper edge of the beach. The lower unit is composed of laminated silt, clay and fine sand. The upper unit is a peat. Both of these units can be traced for about 0.4 mile towards the east although occasionally interrupted by drift, mostly till, cropping out at beach level. Still further towards the east, the bluffs, composed for the most part of Montauk Till, reappear.

Rooted stumps are occasionally found on the peat layer. About a mile to the northeast, adjacent to East Lake Drive and Montauk Harbor, the U.S. Geological Survey notes 98 feet of clay commencing at elevation 0 (Well S010041). The evidence so far developed suggests the entire Montauk Harbor swale was at one time a lake basin. A pollen section from the beach exposure worked up by Maurice Kalisky, one of our graduate students, indicates the sampled section straddles the B (pine) and C-1 (oak-hemlock) Pollen Zones. In this and other aspects, this pollen section resembles that of Donner's (1964) site 2 section from a bluff 0.3 mile west-northwest of Montauk Point. Apparently, a proglacial lake developed a bog sere in postglacial times which was terminated by the Flandrian transgression. The rise in sea level breached the basin rim and littoral and aeolian sand encroached upon portions of the original basin.

Return to Route 27. FULL STOP!

Plate 1

Plate 1. Vertical aerial photograph of a portion of Hither Hills, Montauk Peninsula. Long Island's south shore showing fringing dunes adjacent to wave-cut bluffs appear in the lower portion of the picture. STOP 6 is the excavation in the upper right portion of the photo. The east-northeast-striking lineaments are "push" or "thrust" moraines.

130.4	0.5	Left (west) on Route 27.
131.7	1.3	TRAFFIC CIRCLE. Right (north) onto Edgemere Road. Fort Pond on your left is dammed on both its north and south side by tombolos.
132.8	1.1	Montauk Station: eastern terminus of the Long Island Railroad. Bear right onto Flamingo Road.
132.9	0.1	Left into Sand Pit.
		<u>STOP 5.</u> 30 minutes.
		This excavation illustrates the internal structure of a morphologically well-defined ice-contact kame. Till is exposed at the north side of the pit while a lag concentrate and loess overlie the glacial drift.
134.1	1.2	Return to Route 27 at traffic circle. Montauk Village Traffic Circle. Turn right (west) onto Route 27.
134.7	0.6	Intersection with Old Montauk Highway. Stay right on Route 27 (New Montauk Highway).
135.9	1.2	Right turn onto access road into <u>Montauk Sanitary Landfill Project</u>. Park in designated area.
136.5	0.6	<u>STOP 6.</u> 30 minutes.
		Both the topographic maps and aerial photographs (see Plate 1) of the Hither Hills area feature several dozen northeast striking ridges. Fuller (1914, p.48), referring to the swales between these ridges, called them "inner-fosse channels". He considered them to be erosion channels which were outlets for waters issuing from the ice margin at successive halts and escaping parallel to the ice front. The structure of the stratified drift exposed in this excavation, however, suggests these ridges are ice-thrust moraines. On the west side of the excavation access road, coarser stratified drift, a lag concentrate, and loess are exposed.
137.1	0.6	Return to Route 27. Turn right (west) on Route 27.
139.2	2.1	In clear weather, the view towards the west gives an excellent view of the Ronkonkoma moraine as well as many grosser shoreline features.
140.7	1.5	Intersection of New and Old Montauk Highways. Continuing west along Route 27, note the wave-cut bluff to your right (north) now isolated from the sea by a prograding shore. The bluff section consists of stratified drift overlain by dune sand now cascading down onto the Long Island Railroad right-of-way. These dunes appear to have migrated in from the north shore.

141.4	0.7	Intersection of Route 27 with "Four Wheel Drive". Dismount buses. Walk north 0.9 mile north on "Four Wheel Drive". Note the dune topography of the east end of the Napeague Tombolo. At the terminus of the paved road, follow path to top of "Walking Dune".
		STOP 7. "Walking Dune". 30 minutes.
		These magnificent parabolic dunes are the present result of a series of morphological developments. Initially, a spit was built westward out from the north shore of Hither Hills. Foredunes were then built behind the beach associated with the spit. Meanwhile, a tidal marsh sere developed in the lagoon behind the spit and the dunes encroached upon and, in large measure, covered the tidal marsh. An oak forest sere developed within the dune swales but were subsequently covered and still later exhumed. Note the dune slip faces currently burying the existing forest.
		Return to buses. Continue west on Route 27.
146.3	4.9	Right turn onto Napeague Meadow Road.
146.4	0.1	UNGUARDED RAILROAD CROSSING-CAREFUL!
		Crossing Napeague Meadows, a ditched tidal marsh.
147.7	1.3	Left turn onto Cranberry Hole Road.
147.9	0.2	Roadcut through Promised Land Chenier.
148.8	0.9	Promised Land fish-rendering plant on right; chenier on left (south). The road parallels the chenier for 1.5 miles.
150.3	1.5	"Cross Road" intersection. Continue on Cranberry Hole Road. The chenier ties into the Ronkonkoma Moraine at the east end of the wave-cut bluff marked by Bluff Road. Presumably, the chenier marks the location of a former spit built eastward at the time the sea was eroding along the line of bluff road.
151.2	0.9	CAREFUL! NARROW BRIDGE over Long Island Railroad.
151.4	0.2	STOP! DANGEROUS CROSSROAD! Cross Route 27 obliquely onto Bluff Road. Bluff Road follows the crest of a wave-cut cliff cut into outwash. Some might suggest that the flat below the bluff represents a mid-Holocene three-meter terrace in the sense of Fairbridge. However, it is more likely that the flat is due to prograding Atlantic shore in this vicinity. The present shore cuts the bluff out at Easthampton village.
152.2	0.8	STOP 8. Bluff Road. 30 minutes.

Plate 2

Plate 2. High oblique aerial photograph viewing STOP 8 and vicinity towards north. From the Atlantic Ocean north, note Napeague Beach, the extreme west end of the Napeague beach-dune tombolo complex, the Bluff Road wave-cut cliff, outwash apron (cultivated fields), the Ronkonkoma Moraine (wooded area), and Gardiners Bay in the distance. Photo by Ernest Filep, USNR.

Plate 2 depicts the morphological relationships of the locality. Time permitting, we will walk the 0.4 mile to the Atlantic shore beach. Mount buses for return trip to Sheraton Tenney Inn.

153.0	0.8	Right turn onto Indian Wells Highway.
153.3	0.3	Left onto Further Lane.
155.9	2.6	Intersection with Route 27 at flagpole. Retrace route back to NYSGA Headquarters.
255.2	99.3	Sheraton Tenney Inn.

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