

GEOLOGY, GEOMORPHOLOGY, AND LATE-GLACIAL ENVIRONMENTS  
OF WESTERN LONG ISLAND, NEW YORK

OR

SUBURBAN PLEISTOCENE GEOLOGY: WHO BUILT A PARKWAY  
ON MY BOG?

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INTRODUCTION

The glacial geology and geomorphology of western Long Island were first studied in detail by Woodworth (1901) and Fuller (1914). Supplementary and more recent work has been contributed by de Laguna and Perlmutter (1949), Swarczewski (1963) and Perlmutter and Geraghty (1963), among others. The reconstruction of late-Wisconsin and postglacial environments in western Long Island is based mainly on the relationships between the glacial deposits, geomorphology, and radiocarbon dated pollen stratigraphy. The pollen stratigraphy and chronology for this region (Sirkin, 1965) show consistent similarities to the late-glacial and postglacial pollen stratigraphy and chronology of southern New England (Deevey, 1958) with notable exceptions: (1) a longer and presumably more nearly complete late-glacial record is found in the vicinity of the terminal moraine (i. e., near the southern limit of late-Wisconsin glaciation), (2) deglaciation began earlier in the terminal moraine region than to the north in New York and New England, (3) the pollen record begins with pollen spectra indicative of parktundra vegetation, rather than the high Arctic tundra suggested in southern New England (Leopold, 1956; Ogden, 1959), and (4) the pollen zones, at least through subzone B2 (pine, oak), begin earlier in western Long Island and are time transgressive into southern New England. Finally, correlation between the pollen record, glacial geology, and geomorphology provides a means of interpreting the late-glacial physical environment.

PRE-PLEISTOCENE GEOLOGY

The oldest stratigraphic units in western Long Island consist of metamorphic rock, probably of lower Paleozoic age, which crop out along the East River in Queens and are found at increasing depth below the much younger Mesozoic and Cenozoic deposits of the continental shelf-coastal plain sedimentary wedge to the east and south (Table 1). Along the northern shoreline of western Long Island and offshore in Long Island Sound, depth to the metamorphic basement varies between 50 feet and 250 feet below sea level.

Cretaceous and younger strata, including possible Tertiary marine sediments, late-glacial drift, and estuarine deposits, disconformably overlap the metamorphics. The oldest Cretaceous deposit in this region, the Lloyd Sand member of the Raritan Formation, is not found at the surface. Cretaceous variegated clays and sands of Raritan and/or Magothy age crop out in the base of bluffs along the north shore. These beds, which contain fragments or nodules of fossiliferous (mainly plant debris)

TIME UNITS: PERIOD	EPOCH	STAGE	SUBSTAGE	REVISED STRATIGRAPHIC UNITS FOR LONG ISLAND
QUATERNARY	HOLOCENE	RECENT	POSTGLACIAL	PEAT, SILT
	PLEISTOCENE	WISCONSIN	LATE-GLACIAL VALDERS TWO CREEKS PORT HURON CARY	LACUSTRINE AND MARINE SILT AND CLAY
			pre-CARY	HARBOR HILL DRIFT RONKONKOMA DRIFT  (may include the MANHASSET FORMATION HEMPSTEAD GRAVEL MONTAUK TILL HEROD GRAVEL)
			SANGAMON	JACOB SAND GARDINERS CLAY
			Pre-SANGAMON (?)	JAMECO GRAVEL unconformity MANETTO GRAVEL unconformity
CRETACEOUS	UPPER  CRETACEOUS	SANTONIAN  TO CENOMANIAN	MAGOTHY FM RARITAN FM. CLAY MB.  LLOYD SAND MB unconformity	
LOWER PALEOZOIC				CRYSTALLINE BASEMENT

TABLE 1: TENTATIVE REVISION OF THE STRATIGRAPHY OF WESTERN LONG ISLAND

siderite and red sandstone, iron oxide concretions and pipes, lignite lenses and marcasite nodules, are highly deformed and discontinuous units where they crop out. Due to glacial erosion and deformation and coastal slumping of large blocks, the exposed sections vary in the sedimentary units which they contain. In places, till rests directly on Cretaceous strata, while in other sections outwash and/or a white sand unit separate the till and the Cretaceous clays. (See Plate 2, figures 3 and 4). The regional dip of the pre-Pleistocene beds as projected from well cores is less than one degree to the southeast, but is sufficient to produce a northwest-facing cuesta.

A fine to medium grained, apparently unfossiliferous, and partially indurated white sand layer may be somewhat angularly unconformable to the underlying Cretaceous. This unit physically resembles certain upper Cretaceous and Tertiary units of the New Jersey and Massachusetts coastal plain.

### PLEISTOCENE GEOLOGY

Pleistocene deposition accounts for up to 150 feet of sediment mantling the former Cretaceous upland. Evidence of pre-Wisconsin glacial deposition in Long Island includes the Manetto Gravel, a bedded gravel containing erratic pebbles, and the Jameco Gravel, a diabase rich gravel. Both of these gravels are encountered in wells in western Long Island and at the surface in the Dix Hills area in central Long Island, and are considered to be outwash gravels (Table 1). The superposed tills and gravels in Block Island, Martha's Vineyard and Cape Cod, which have been described by Woodworth and Wigglesworth (1934) as representing two or more classical glacials, apparently have no correlative exposed in western Long Island.

A marine or lagoonal clay and sand unit, the Gardiners Clay-Jacobs Sand, mantles the gravels and has been placed in the Sangamon interglacial stage on the basis of microfossil flora, indicating a cold-warm-cold temperature sequence and consisting of diatoms and pollen (Donner, 1964), and on the basis of fauna (mollusks and foraminifera) correlating with the Cape May Formation in New Jersey (MacClintock and Richards, 1936).

In the classical study of Long Island geology by Fuller (1914), the lower Wisconsin is represented by the Manhasset Formation which comprises the Herod Gravel, Montauk Till, and Hempstead Gravel members. This sequence would reflect glacial advance and recession, if interpreted as a till bounded by outwash gravels. The Montauk Till member underlies younger drift in well-sections in western Long Island and in the sea cliffs of southeastern Long Island, a fact documented by the other workers in this area.

Another clay layer, apparently younger than the Gardiner's Clay, is the 20-Foot Clay. This deposit is found in south shore well-sections and in buried stream channels inland, but it is not found on the north shore (Perlmutter and Geraghty, 1963). This clay may be the result of a Wisconsin interstadial (Plum Point equivalent?) episode on Long Island.

The upper Wisconsin ice sheet is generally thought to have occupied its southernmost boundary in northeastern North America well before 18,000 B.P. (years before the present). Recession from this position began possibly before 17,000 B.P. as suggested by sea level curves (Fairbridge, 1961). The exact age

# FIGURE 1: LATE-PLEISTOCENE GEOLOGY

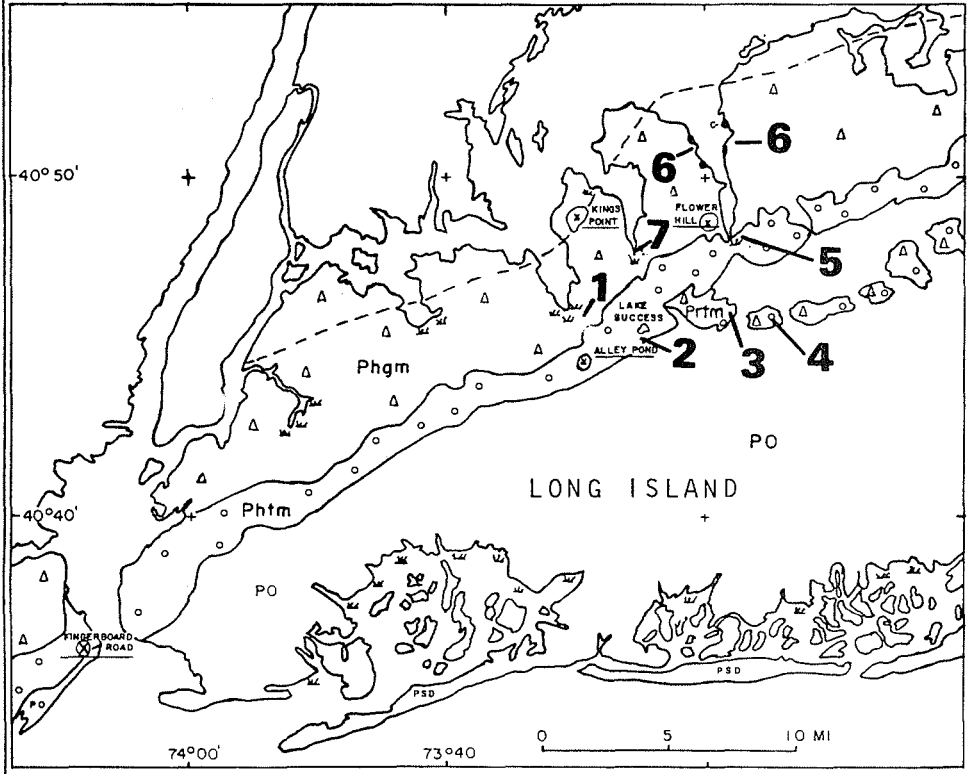
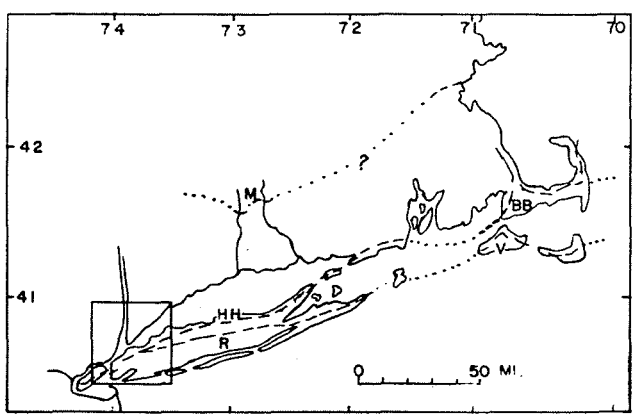
## WESTERN LONG ISLAND - EASTERN STATEN ISLAND, NEW YORK



(after Fuller, 1914; Swarzenski, 1963; Staten Island Surficial Geology Sheet, 1901)








### INSET (at left): GEOGRAPHIC CORRELATION OF MORAINES IN SOUTHERN NEW ENGLAND - NEW YORK

(after Flint, 1953, in Ogden, 1959)

M= MIDDLETOWN, HH= HARBOR HILL, BB= BUZZARDS BAY, R= RONKONKOMA, V= VINEYARD



- 
STUDY AREA ON INSET AT LEFT
  - 
BOGS STUDIED

FLOWER HILL  
ALLEY POND  
KINGS POINT  
FINGERBOARD ROAD
  - 
SHORELINE DEPOSITS  
MARSH and BEACH
  - 
UNDIFFERENTIATED OUTWASH
  - 
HARBOR HILL GROUND MORAINES  
and STRATIFIED DRIFT
  - 
HARBOR HILL TERMINAL MORAINES
  - 
RONKONKOMA TERMINAL MORAINES
  - 
PRE-PLEISTOCENE CLAY DEPOSITS
  - 
ICE STAND ON THE NECKS
- POST and LATE-GLACIAL

LATE-PLEISTOCENE

of the recession has, as yet, not been determined due to lack of success in finding, and/or determining, the age of the organic samples from the moraines or from the basal sediments of bogs lying on the moraines. The late-Wisconsin interval covers the time during which the terminal moraines and associated outwash were deposited in Long Island, and during which glacial erosion and deformation of the underlying sedimentary units occurred. The late-glacial interval encompasses the time of recession and minor fluctuations of the ice margin.

The moraines of western Long Island are the Ronkonkoma Moraine and the Harbor Hill Moraine (Figure 1). The Harbor Hill Moraine marks the terminal position of the late-Wisconsin ice sheet in western Long Island and generally is presumed to overlie the older Ronkonkoma Moraine, which according to well data (Swarzenski, 1963) trends west north-west under the Harbor Hill drift. The Ronkonkoma Moraine according to Fuller (1914) also overlies till and gravel of the Manhasset Formation.

However, inspection of new cuts in the Ronkonkoma and Harbor Hill Moraines has failed to reveal a complex situation involving more than 2 tills. It appears that the Ronkonkoma Moraine is composed of kame-like deposits which are underlain by a sandy gray-brown till (Montauk equivalent?) which grades southward into stratified drift (see Plate 1, figure 5 and Plate 2, figures 1 and 2). The stratified drift above this till varies considerably in grain size, ranging from coarse gravels to fine cross-bedded sands. There is also evidence that till of Harbor Hill age was deposited in places over the older drift so that the Ronkonkoma Moraine may be capped by this younger till. Plate 1, figure 5). The lower till, presumably the Montauk Till, may be traced northward below the outwash and has been described from north shore sand pits (Fuller, 1914) and, as previously mentioned, in north shore wells. The Harbor Hill Till (Plate 1, figure 1). is a less sandy and more oxidized till than the Montauk Till. Both contain a variety of lithologies, but the Harbor Hill Till appears to contain a wider range of sedimentary sizes - from clay to large erratics, and a more pronounced flow (or solifluction) structure.

In the Harbor Hill Moraine, the Harbor Hill Till, which varies in thickness up to 50 feet, overlies stratified drift which has been described as outwash deposited during the recession of the glacier from the Ronkonkoma terminus (Fuller, 1914). Woodworth (1901) also describes a boulder bed (which has subsequently been removed in quarrying) in the late-Pleistocene sequence in the Port Washington sand pits. This unit may have been a lag deposit formed during the same interval.

Both the Ronkonkoma and Harbor Hill Moraines, therefore, are composites of till and outwash and both attain their greatest relief over the former Cretaceous uplands. The Harbor Hill Moraine and the Ronkonkoma Moraine diverge east of Lake Success, a large kettle lake in western Long Island. The Ronkonkoma Moraine extends eastward to Montauk Point, and the Harbor Hill Moraine trends northeastward toward the north shore (Figure 1).

Recessional deposits formed during glacial recession north of the terminal moraine include late-glacial outwash sand and gravel, till or ground moraine intercalated with gray clay lenses, and delta and kame deposits. The till, which varies in thickness up to 20 feet, is exposed in the north shore sea cliff sections, railroad

SUBSTAGES AND CLIMATES		POLLEN ZONES		AGE B.P	SOUTHERN NEW ENGLAND	FLOWER HILL	ALLEY POND	KINGS POINT
POST GLACIAL	SUBATLANTIC moist and cooler	OAK	C3b	1000	sp,pi rise	oak,ch,bi, ma	ch,bi,c-t	oak,bi,nap
			C3a		oak,hem,ch	oak,pi,hic gr,sd,hol	oak,ch,bi, hol	bi,hem,nap, hol
	SUBBOREAL warm,dry		C2	2000	oak, 2b hic, 1b	oak,hic,2b hem, 1b	oak,ch,hic, wil,pi, 1b	oak,bi, hem wil
	ATLANTIC warm,moist		C1	5000	oak,hem	oak,hem,gr	oak,ch,hem	oak,ch
	BOREAL warm,dry		B2	6000	pi,oak	pi,oak,gr	pi,bi,nap *9250±100	pi,oak,gr
B1	pi,sp	pi,bi,c-t						
VALDERS	VALDERS cool	SPRUCE	A4	8500	sp returns	sp,pi,fir, sbi,gr	*10100±400 pi,sp,fir, gr	pi,sp,bi *11150±300
TWO CREEKS	TWO CREEKS cool		A3		pi,sp,oak			sp,pi,bi
PORT HURON	RECESSION cold		A2	12000	bi,sp	pi,sbi,nap	sp,pi	spi,bi,nap
			A1		sp incr			sp,pi incr
CARY	LATE-GLACIAL	HERB	T3	13000	hi nap-pi, bi pk-tun	nap incr- gr,pi,sp	sp,spi, bi,gr	gr,pi,sp
			T2		13500	sp pk-tun		sp,pi,bi
			T1	13800	hi nap- pi tun	pi,sp,sbi, nap incr-gr	gr,wil, sbi	pi,gr, sbi
			W3	15000	glaciated	pi,bi,sp	spi,nap, sbi	pi,sp,fir
PRE-CARY	HARBOR HILL RECESSION	w2b	17000			hi nap, gr, bi wil,bi, gr,sd	glaciated	glaciated
		w2a						

TABLE 2: CORRELATION OF WESTERN LONG ISLAND-EASTERN STATEN ISLAND POLLEN STRATIGRAPHY AND CHRONOLOGY WITH SOUTHERN NEW ENGLAND. (Southern New England pollen stratigraphy and chronology from Deevey, 1957. \*Radiocarbon dates in this study.)

KEY:

sp=spruce, pi=pine, spi=small pine, bi=birch, sbi,small birch, ma=maple, hol=holly, 1b-2b=beech maxima, wil=willow, hem=hemlock, ald=alder, ch=chestnut, hic=hickory, gr=grass, sd=sedge, pk=park, tun=tundra, c-t= cat-tail.

cuts, and sand borrow pits. The recessional till mantles the upland of northwestern Long Island where it overlies outwash sand and gravels. The outwash gravels also show evidence of flowage or folding, but as a competent unit, which might have occurred if this unit was frozen during deformation (Plate 2, Figure 5). Periglacial (permafrost or solifluction) features are also seen in excavations in the ground moraine of northwestern Long Island. Near the heads of the north-south valleys, kames are found, generally on the southeast side of the valley. These deposits are composed of sands and gravels with well developed ice contact features (Plate 2, Figure 6).

Other late-glacial deposits include aeolian, lacustrine, estuarine, and marine sediments formed on the surface of the drift or on pre-drift strata or in lakes and estuaries and in Long Island Sound. The postglacial interval is represented mainly by peat formed in bogs and in salt and fresh water marshes. It is from these units that the late-glacial and postglacial environments are being reconstructed.

### GEOMORPHOLOGY

Western Long Island is divided physiographically into two provinces, the "terminal moraine region" and the "outwash plain," both of which are oversimplifications. The northern half of the island is dominated by the Harbor Hill Moraine which forms the highest hills, for example, Harbor Hill in Roslyn and the major east-west divide across the island. North of the Harbor Hill Moraine, the upland is sculptured into low, semi-elliptical, partially flat-topped hills mantled by glacial drift. Major extensions of the upland northward into Long Island Sound form the so-called necks of the north shore, which are separated by steep walled partly silted-in troughs. The valleys open out northward to form bays of Long Island Sound. East-west through drainage valleys cut across the necks at their southern margins and also at about three-fourths the distance to the Sound (Figure 1). The necks are also divided into secondary north-south lobes which have drumlinoid shapes, but with oversteepened slopes overlooking Long Island Sound. Smaller drumlinoid hills, such as College Point, Fort Totten and Douglaston, as well as a small drumlin in the Manhasset valley, conform to the north-south axial trends.

The presence of the bays, which occupy the former glacial troughs, of drumlinoid hills, which are deformed Cretaceous and Wisconsin deposits marginal to the bays, and of kame deposits at the heads of the valleys, suggests that glacial erosion, deformation, and deposition were the dominant forces involved in the development of the valleys. Furthermore, the oversteepened north-facing bluffs indicate recent sapping of the cliffs and possible postglacial emergence.

The history of the troughs is more complicated. The alignment of the valleys with the bedrock valleys of southern New York and New England, the existence of aligned, buried drainage channels beneath glacial drift of Long Island, and the presence of topographic highs on the buried Cretaceous and Tertiary erosion surfaces may be evidence of well established pre-Pleistocene drainage across the coastal plain. The valleys may have been inherited from a former drainage pattern, which persisted not as antecedent streams, but as topographic lows during successive depositional episodes. Subsequent glacial activity has only accentuated the valley segments north of the moraines. The moraines have dammed-up the southeasterly flowing drainage.

## LATE - WISCONSIN EVENTS

The present surface of western Long Island may be interpreted as the result of continental glaciation during the late-Wisconsin, which deformed the existing deposits and deposited the drift. The following sequence of events is suggested, based on the glacial stratigraphy. The lower till unit of the Ronkonkoma Moraine, *viz.*, the Montauk Till, was deposited during the major glacial advance into the Long Island region, following the mid-Wisconsin interstadial, correlative in time with the Plum Point. A stationary ice front deposited the kame deposits over the till, prior to the recession of the ice front northward at least to the northern edge of Long Island. During this episode a thick sequence of outwash deposits was formed north of the Ronkonkoma terminus. Glacial meltwater was channeled eastward between the ice front and the moraine, breaching the moraine at numerous points.

Subsequently, the glacier readvanced over the post-Ronkonkoma deposits and on western Long Island over the Ronkonkoma Moraine, and deposited the Harbor Hill Till and contemporaneous outwash to the south. As suggested previously, these events occurred during pre-Cary time, possibly during the classical Tazewell substage of the Wisconsin. Radiocarbon ages obtained for pollen zones (see, Pollen Stratigraphy) in this area and in southern New York, also indicate a Tazewell age for this activity (Connally and Sirkin, 1967).

The Harbor Hill advance for which surficial trends can be examined appears to be the result of glacial lobes following the major drainage systems. The Harbor Hill Moraine on western Long Island, Staten Island and New Jersey, clearly represents the terminus of the Hudson River lobe. Further east on Long Island, the moraine may have originated in the Connecticut River lobe of the glacier. Lobate segments of the moraines in central Long Island may represent coalescence of lateral deposits of the two glacial lobes.

The events associated with the recession of the Harbor Hill ice may be incorporated within the framework of: (1) ablation of the glacier through regional down-wasting, (2) recession of the glacial terminus to the northern edge of Long Island, followed by glacial stillstand and deposition of deltas in marginal lakes (Woodworth, 1901), (3) minor advance of the ice within the troughs, sculpturing the valleys and depositing kames and outwash in the valleys, and (4) final recession of the ice from Long Island, with this sequence of events possibly taking place during late Tazewell and early Cary time.

The problem of the origin of Long Island Sound, as it affects the geomorphic development of western Long Island, is made difficult by the lack of detailed study of deep cores and basement profiles in the Sound. Geologic cross sections of Long Island (Perlmutter and Geraghty, 1963) indicate a Cretaceous cuesta buried by late-glacial and postglacial estuarine deposits, underlying the present Sound. This evidence, in conjunction with the through-valley structure between southern New York and Long Island, suggests that the postulated pre-Pleistocene drainage network consisted of consequent north-south and subsequent east-west rivers, including a Long Island Sound River developing after regression of the Cretaceous sea. Pleistocene (at least late-Wisconsin) modification of this pattern occurred during glacial deposition and through the formation of marginal glacial lakes during glacial recession. The morainal barrier across the Hudson trough created proglacial lakes in New Jersey and probably in Long Island Sound (Newman, 1966). In addition, west to east meltwater drainage from the Hudson trough, running through the Sound valley, deepened the valley, and cut through the moraines to the east.



## POLLEN STRATIGRAPHY AND LATE GLACIAL ENVIRONMENTS

Evidence for interglacial or intraglacial vegetation and environments is at present lacking in western Long Island. The pollen record begins with lake sediments (i.e., clays and silts) deposited on Harbor Hill drift in conjunction with glacial recession from the Harbor Hill terminus. The late-glacial and postglacial pollen stratigraphy and chronology are summarized and correlated with that described by Deevey (1958) for southern New England (Table 2). The correlation indicates that the zonation in this study may be associated with a sequence of events that in part precedes the late-glacial record (the T zones) in southern New England. The pollen subzones of the Herb Pollen Zone (Davis, 1965) for this early interval in Long Island are designated (tentatively) by the letter W, and three subzones W2a, W2b, and W3, are recognized. The W1 subzone, which is not recognized in this study, is reserved for the interval following the deposition of the Ronkonkoma moraine.

The oldest subzone found here is W2a, represented in the Flower Hill section. The pollen assemblage of willow, large and small birch, large and small pine, grass, and sedge represents tundra-like vegetation where the characteristic plants are moss, grass, and shrubs (Table 2). Since the AP (arboreal pollen) represent over 50 per cent, a park-tundra, rather than a pure tundra vegetation is suggested. The large birch and pine pollen may indicate invasion of the outwash plain by these trees from the coastal plain to the south. The presence in the W and T subzones of deciduous-tree pollen, such as oak, chestnut, and beech, is regarded as either evidence for transport from the deciduous forests to the south of the moraine or (less likely) for redeposition of this pollen from the glacial sediments. At the time of subzone W2a, the glacier was receding from the Harbor Hill position.

The high percentages of NAP (Non-Arboreal Pollen) and large birch pollen in subzone W2b imply a continuation of the glacial environment and near-tundra vegetation of zone W2a and establishment of the vegetation indigenous to the bog. The NAP increase, mainly in grass, sedge, cat-tail, and Plumbaginaceae (cf. Armeria) and Polygoniaceae (cf. Polygonum), suggests a moist, cold climate resulting from the presence of ice on northwestern Long Island. It is significant that subzones W2a and W2b are identified in the Flower Hill section but not in the Kings Point section to the north. This sequence provides additional evidence of the northward recession of the glacial front and a stillstand just south of Kings Point in subzone W2b time. The first zone appearing in the Kings Point record is subzone W3, which correlates across the study area as a pine-spruce-fir-birch-NAP assemblage. The persistent relatively high percentage of grass pollen in this spectrum is good evidence of park or park tundra vegetation.

The glacial stand along the northern edge of Long Island was previously recognized by Woodworth (1901) as resulting in the formation of proglacial lakes and associated deposits, such as the Port Washington delta. Cutting of the east-west drainage lineation marginal to the ice on northwestern Long Island (Figure 1), also occurred at this time. It is suggested that the subzone W events occurred in pre-Cary time.

The T subzones of the Herb Pollen Zone reflect continued cold environments during glacial recession from the study area into southern New York and New England during subzone T1, based on a pollen spectrum of pine, spruce, shrub birch, and NAP, indicates a park-tundra in the study area, correlative with southern New England (Table 2).

Coupled with the glacial evidence (i.e., erosion, deformation and deposition features) in the bays of northwestern Long Island, it appears that a minor readvance during the subzone W3 stillstand and prior to the subzone T1 recession sent ice tongues up the troughs, possible to the heads of the valleys. Following this last pulse western Long Island appears to have been ice-free during subzone T2 with the ice front receding into New England.

Subzone T2 represents evidently more of a parkland setting in which spruce, pine, and birch are dominant, accompanied by a decrease in the NAP. The climate in the study area is interpreted as warming, as glacial recession continued until the glacial front was north of the Middletown moraine site in central Connecticut. The pollen stratigraphy of subzone T3 is similar to that of subzone T1, including the increase in NAP, particularly grass, which at Kings Point amounts to nearly 50 per cent of the pollen. The return of a more open parkland is correlated with the presumed glacial readvance to the Middletown site in Connecticut during Cary time.

Glacial recession at the onset of the Spruce Pollen Zone (Davis, 1965) continued northward in Port Huron time. In the study area, subzone A1 of the Spruce Pollen Zone, with increasing proportions of spruce, grades upward into the pine, birch assemblage of subzone A2. The A3 and A4 subzones are not as clearly differentiated as in southern New England. In western Long Island subzone A3 grades upward into subzone A4, where the spruce increase occurs. Variations in pollen profiles are the result of the more southerly location than New England. For example, the increase in pine in subzone A4 indicates that the pine succession probably began in the Long Island area earlier than in southern New England as the ice front receded into northern Canada.

The A3 subzone in southern New England is correlated with the late-glacial Two Creeks Interstadial, which has a pine, spruce, oak pollen assemblage and a radiocarbon age of  $11,850 \pm 140$  years B.P. (Broecker and Farrand, 1963). Subzone A4 in the northeastern United States, with the rise of spruce, is correlated with the Valders glacial substage at the close of the late-glacial (Deevey, 1958). The radiocarbon ages of  $11,150 \pm 300$  years B.P. (L-738) for the A4 subzone at Kings Point, and  $10,100 \pm 400$  years B.P. (L-868D) for the A3-A4 subzone at Alley Pond fall within the range of the established ages of these zones.

The climatic amelioration that began toward the end of the Spruce Pollen Zone sequence prevailed during the Boreal substage of the postglacial. The designation of the Pine Pollen Zone or B subzone in this study is substantiated by the maximum percentage of large pine pollen and by the radiocarbon age of  $9,250 \pm 100$  years B.P. (L-868C). The warm and dry postglacial climate is reflected in the pollen record, along with later stages of bog development initiated by a lowering of the water table during drier conditions.

The rise of oak in the upper part of the Pine Pollen Zone marks the beginning of the succession of hardwood forests and the decline of the boreal vegetation. A radiocarbon date of 6,600 + 700 years B.P. (L-617) from a peat 16.5 meters below present sea level at Flushing Meadow, indicates that near the Oak Pollen Zone transition, sea level was about 16 meters below its present level. Increased atmospheric moisture and higher ground water levels resulting from the rise of sea level and closer proximity of the shore line are apparent in the Atlantic substages. The dominance of the oak-hemlock forest is characteristic of the vegetation of the C1 subzone throughout northeastern North America. Variations in the pollen record, including chestnut, and Sphagnum, are interpreted as indicating warmer and moister conditions with an increase in ground-water level and the development of standing water in the bogs. The eastern deciduous forest, which extends from southern New England through the Appalachian Mountain region, appeared in the study area during subzone C2, oak-hickory succession, typical of the Sub-Boreal climate.

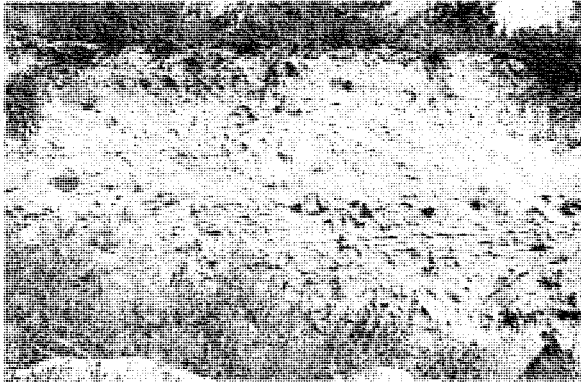
The NAP increases during subzone C3 began approximately 2000 years ago, according to a radiocarbon age of 2,025 + 250 years B.P. (1-510) for the base of C3a subzone in the Hackensack Marsh of northeastern New Jersey (Heusser, 1963). Subzone C3 is associated with the moist, cool environments of Sub-Atlantic time. The lower C3a subzone is characterized by an oak, hemlock, chestnut assemblage in southern New England. In Long Island oak declines and chestnut is not significant. The NAP rise is related to a rise in water table. The peak of holly in this subzone throughout this region and in northeastern New Jersey (Heusser, 1963) supports the inference of increased moisture.

In subzone C3b, oak again increases, but the spruce and pine increases recorded in southern New England are not seen here, although pine is present. Increase in birch and chestnut reflect the cool, moist climate, while the rise of the composites is seen as the direct result of settlement and clearing, which began about 400 years ago. The growth of peat and the invasion of the bog mats by arboreal vegetation occurred mainly during subzone C3 time.

#### SUMMARY

Correlation of the pollen stratigraphy from sedimentary sections located on or near the southern glacial margin in western Long Island, with the late-glacial drifts, aids in the reconstruction of geologic, climatic, and vegetational trends associated with glacial recession. The southern limit of this glaciation is represented by moraines presumed to be of pre-Cary age in southern New York. Glacial recession is represented by glacial drift of Cary and Port Huron age north of the glacial margin.

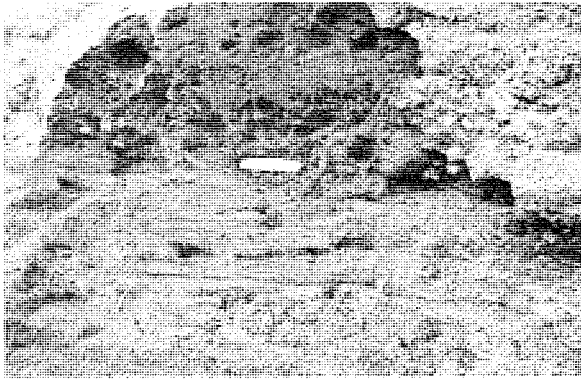
The late-glacial Herb Pollen Zone subzones (the W sequence) indicate the presence of park-tundra vegetation succeeded by tundra-like vegetation, in the vicinity of the moraine and following a recession, a minor readvance, and final recession from the terminal moraines. Tundra conditions are recorded in the T subzones in southern New England in Cary and early-Port Huron time, so that the Herb Pollen Zone appears to transgress late-glacial time. This zone is generally succeeded by the Spruce Pollen Zone, comprised of varying proportions of spruce and pine, as early as late-Cary time in the region of the terminal moraines.



-1



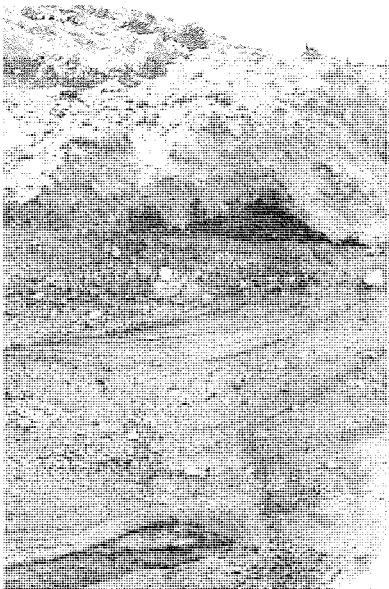
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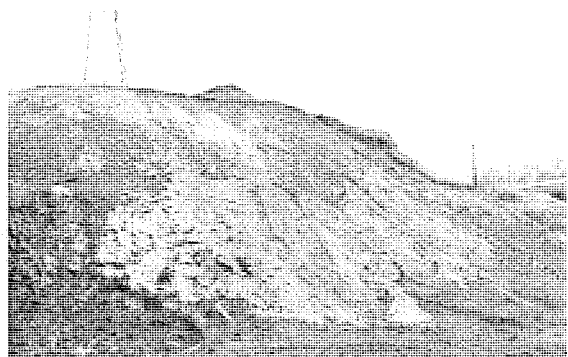
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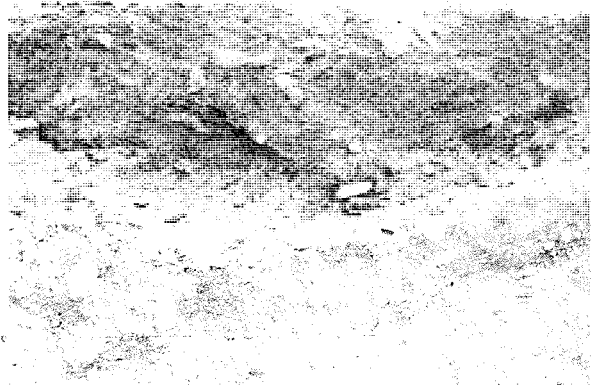
**PLATE 1**

## Plate 1.

- Figure 1. Harbor Hill Till, Little Neck.
- Figure 2. Harbor Hill Till over thin bedded sand and clay, Lakeville Road - Northern State Parkway.
- Figure 3. Same. Contact of till and bedded sequence.
- Figure 4. Same. Detail, clay partings.
- Figure 5. Ronkonkoma Moraine. Till (cf. Harbor Hill) over cross bedded sand and gravel. Willis Avenue - Northern State Parkway.
- Figure 6. Harbor Hill Till over outwash; contact near break in slope, Harbor Hill, Roslyn.



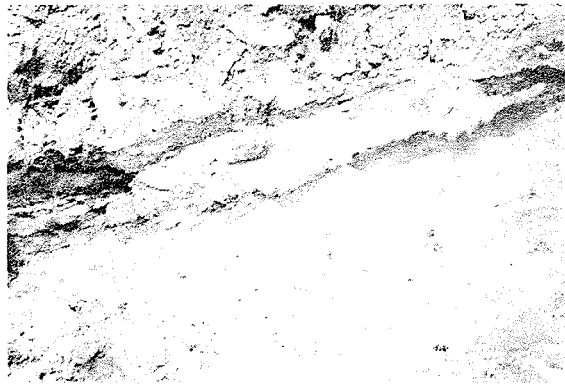
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PLATE 2

## Plate 2.

- Figure 1. Ronkonkoma Moraine. Coarse outwash over till (cf. Montauk Till). Roslyn Road - Northern State Parkway.
- Figure 2. Same. Detail of contact: outwash over till.
- Figure 3. Coastal slump blocks. Till over white sand. Garvies Point.
- Figure 4. Same. Detail of contact, till over white sand.
- Figure 5. Folded(?) outwash. Manhasset.
- Figure 6. Ice contact features. Kame, Manhasset Valley.

Dominance of spruce, pine, and birch occurs in the subzone A sequence while the ice front receded through New England. The Pine Pollen Zone or B subzone is identified by a pine maximum beginning earlier in the study area than in southern New England, according to radiocarbon ages. Variations between the Oak Pollen Zone (C subzones) in this study and those in New England result from local climatic and ecologic factors.

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### ROAD LOG

#### Mileage.

- |      |     |  |
|------|-----|--|
| 0.0  | 0.0 | Leave La Guardia vicinity. Follow 94th St. and then Junction Boulevard south to the Long Island Expressway (L.I.E.) eastbound.   |
| 2.6  | 2.6 | Follow L.I.E. eastbound: Note crossing Flushing Bay, a glacial trough which may be linked to the Bronx River valley on the Bronx side of the East River.   |
| 9.7  | 7.1 | Exit at Douglaston Parkway. Right (south) on Douglaston Parkway to Alley Pond Borrow Pit.  |
| 10.2 | 0.5 | <u>STOP 1.</u> Alley Pond Borrow Pit.<br>This exposure provides an opportunity to observe the lithology and structure of the Harbor Hill Moraine, (Plate 1, figure 1), the till (upper 5 + feet), the Little Neck Bay trough, and from the top of the cut, the New York skyline. Long axes of pebbles from the till point generally NNW. <u>Note:</u> The extension of Little Neck Bay with Eastchester Bay and the Hutchinson River in the Bronx to the north; the drumlinoid hills - Fort Totten on the west side and Douglaston on the east side of Little Neck Bay. Occasionally, the stratified drift below the till is exposed in gullies. A section is also exposed at the northeastern corner of the Korvette shopping center, below 251st St. North of the L.I.E. a small lobe projecting from the valley wall on the east side was dissected in construction. It may have been a small kame. Alley Pond bog is on top of the moraine on the west side of the valley. |
| 10.7 | 0.5 | Return to the L.I.E. via Douglaston Parkway.   |
| 13.0 | 2.3 | Follow the L.I.E. eastbound to Lakeville Road.   |
| 13.4 | 0.4 | <u>LOOK STOP.</u> Lake Success. A kettle lake about 0.4 miles across and about 75 feet deep; several small kettles are located on the west and south sides of Lake Success.  |



Follow Lakeville Road south to the Northern State Parkway. Stop on Lakeville Road just before Parkway.

- 0.3 STOP 2. Lakeville Road - Northern State Parkway. A recent cut for widening of the parkway has exposed a section of the Harbor Hill Moraine comprised of about 5 feet of Harbor Hill till overlying 20 + feet of stratified lacustrine sands with thin clay partings (Plate 1, figures 2, 3 and 4). A lake history is suggested since the results of examination for marine microfossils was negative. No other evidence for a high marine stand effecting deposition along the moraine has been found, other than the suggested wave cut cliff along the distal slope of the moraine (Woodworth, 1901). The kettle topography north and east of this site suggests that the stratified fine grained section was deposited in an ice dammed lake on the distal slope of the moraine at the junction of the outwash plain. Other large kettles developed on the pitted outwash just south of the moraine. This section is located near the junction of the Harbor Hill and Ronkonkoma moraines which may have some relationship to the stratigraphy if ice movement pivoted at this point, calving-off large ice blocks.

0.7 Return to L.I.E. eastbound.

3.3 Exit at Willis Avenue southbound (right turn). Proceed to Northern State Parkway. Stop on south side.

0.2 STOP 3. Willis Avenue - Northern State Parkway. In this cut, northeast of the intersection, a section of 4 to 8 feet of till overlies 10 + feet of cross bedded sands and gravels and very coarse cobbles. (Plate 1, figure 5) This section is in the Ronkonkoma moraine and demonstrates the superposed till (cf. the Harbor Hill Till) over outwash and the kamelike nature of the moraine.

0.2 Return to the L.I.E. eastbound service road.

0.5 Proceed to Roslyn Road.

South on Roslyn Road to Northern State Parkway. Stop on north side of parkway.

0.3 STOP 4. Roslyn Road - Northern State Parkway. Another cut into the Ronkonkoma Moraine, on the northeast side of the road, has exposed the lower till (cf. the Montauk Till). Approximately 10 to 15 feet of till are overlain by 25 to 30 feet of coarse cobbly, outwash (or Kame) deposits (Plate 2, figures 1 and 2). The till when exposed in a drainage trench appeared to grade downward and southward into sandy lenses.

Return north on Roslyn Road to Main Street, Roslyn, to old Route 25 A eastbound to Harbor Hill.

- 20.7 1.8 STOP 5. Harbor Hill, Roslyn. Harbor Hill is the type locality of the Harbor Hill Moraine and the Harbor Hill Till. The contact between the till and the outwash may be examined here (Plate 1, figure 6). The hillside just northeast of Route 25 A (on the east side of the bridge) is underlain by a kame (Swarzenski, 1963). Observe the Hempstead Harbor trough and the borrow pits along the west side of the Harbor in Port Washington. Flower Hill bog is above the borrow pits and is being cut into at this time.

Return to Main Street westbound to West Shore Drive.

- 21.0 0.3 North on West Shore Drive to the Police Rifle Range, passing on the way Bar Beach which was a mid-bay bar before construction of a town beach.

- 24.3 3.3 STOP 6. Police Rifle Range, Port Washington. A stratigraphic section, measured in detail by students of Dr. David Krinsley, Queens College (Dr. Krinsley, personal communication) include from the base: 14 feet 2 inches of poorly sorted, pebbly, medium grained sands, 40 feet 10 inches of white sands, which are often pebbly and streaked with iron and manganese oxide stain, and about 15.5 feet of alternating light and dark sands and gravels. The age of the "white sand" layer is questionable, since it is reportedly unfossiliferous (although Dr. Walter S. Newman reports one Cretaceous spore from this horizon).

Observe Mosquito Cove - Glen Cove Creek to the ENE across the Harbor. This inlet and the low break in the cliffs north of the Rifle Range constitute a portion of the east-west drainage along the glacial stillstand referred to in the text. The Cretaceous crops out at Garvies Point on Mosquito Cove and in the Morgan Park north of that site, but it is not exposed north of the borrow pit. The cliffs to the north in Sands Point are composed of 20 to 40 feet of outwash overlain by a thin layer (5+feet) ground moraine.

- (26.7) (2.4) ALTERNATE STOP 6. Garvies Point. (Described above and in text.) Six miles from Main Street, Roslyn, via Main Street - Bryant Road - Glenwood Road, East Shore Road (Sea Cliff), Prospect Avenue, Glen Avenue, Glen Cove Road and McLaughlin to Garvies Point Preserve. The Preserve, a Nassau County facility, is set aside for archaeological studies, and in addition to exposures of Cretaceous and Pleistocene deposits in the cliff sections, contains paleo-Indian shell middens and a possible Indian fishing site in the Cove. Typically, red, gray, and white clay with lignite lenses, marcasite nodules, and fossiliferous (plants) siderite nodules are exposed at the base of the cliffs. The plant fossils include woody fragments and leaves of fig and magnolia. Preliminary pollen and spore analysis of the clays indicates Raritan or possibly Magothy age. The clays are overlain by a white sand section and/or outwash and/or till (Harbor Hill ground moraine or recessional till) (Plate 2, figures 3 and 4). The attitude of the slump blocks is evident here.

Return to highway, turn left (west) on Beacon Hill Road, follow to Main Street, Port Washington, to Shore Road, south to Plandome Road, west and then south on Bayview Avenue, Manhasset, to Nassau County Department of Public Works parking lot. The route follows scenic Manhasset Bay.

- 29.9      5.6      STOP 7. Manhasset Valley Park - Nassau County Department of Public Works, Manhasset. At this stop, one, or possibly two, separate kames (or kame deltas) are found mantling the moraine consisting of thin till over outwash. The outwash is apparently folded or has flowed (Plate 2, figure 5) and is occasionally exposed in building excavations on Northern Boulevard (Route 25 A). The till is probably recessional or ground moraine of late-Harbor Hill age. The kames exhibit striking ice contact structures (Plate 2, figure 6) and indicate a late Harbor Hill glacial advance which sent tongues of ice up the troughs. This advance is supported by several lines of evidence:

- (1) the presence of kames at the valley heads.
- (2) sculpturing of peripheral deposits (i.e., the drumlinoid hills) and deformation of cliff sections (although the outwash may also have been deformed during the initial Harbor Hill advance).
- (3) Oscillation in the pollen record: The subzones W2 - W3 sequence indicating the stillstand and the return of cold indicators in subzone T1.
- (4) the stillstand evidence including the "deltas" of Woodworth (1901) and the E-W drainage lineation (Figure 1).

Tracing the deposits clockwise around the exposure, observe the kame, next (above the wall) outwash (thin till at top) and kame (fronting on 25 A behind gas station).

- 31.4      1.5      Return to L.I.E. via Community Drive. Note the drumlin (possible) south of lake on east side of road. Note cuts into the moraine while ascending the trough on the proximal slope of the Harbor Hill Moraine.
- 41.4      10.0      L.I.E. westbound to Junction Boulevard.
- 44.0      2.6      Junction Blvd. and 94th Street to La Guardia vicinity.

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