Blow

FRIENDS OF THE PLEISTOCENE

FIELD TRIP GUIDE*

31st Annual Reunion

See this book on Cape Cod

CAPE COD, MASSACHUSETTS

May 25-26, 1968

Leaders

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* Publication authorized by the Director, U.S. Geological Survey

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Note

Busses will leave the Seashore Park Motor Inn parking lot at 7:30 A.M., Saturday morning. Departure Sunday morning will be announced Saturday night and will be decided by the number of stops left over from Saturday.

INTRODUCTION

Detailed mapping of Outer Cape Cod was carried on by the U.S. Geological Survey from 1964 to 1966, and the area includes all of Cape Cod National Seashore. The glacial deposits in the field trip area were laid down in the interlobate area between the Cape Cod Bay lobe to the west and north, and the South Channel lobe to the east. The deposits were derived principally from the South Channel lobe.

We have placed the age of the sediments between 14,000 and 15,000 years B.P. This is based on radiocarbon date of 15,300 ± 800 years B.P. (W-1187) taken from tundra flora by Clifford A. Kaye on Martha's Vineyard, and a series of dates of about 14,000 years B.P. given by Kaye for marine clay north of Boston. Marine shells found in the Cape Cod deposits suggest an ice advance over the area at perhaps 20,000 years B.P. These shells are thought to have been picked up by the ice from areas to the north and subsequently deposited in the stratified drift by melt-water streams during ice retreat.

The beach and dune deposits from Pilgrim Lake to Provincetown have been derived from erosion of the glacial deposits to the south, with subsequent transport by longshore currents and wind action.

FIELD TRIP LOCALITIES

STOP 1. Highland Light and Highland Plains section - contact of the Highland and Truro Plains.

This will be the longest and most difficult walk of the field trip. We will descend the cliff at Highland Light and walk north to Highland Beach, a distance of nearly a mile, where we will be met by the busses. Some may wish to stay with the busses for this stop.

The Highland Section exposed here consists basically of 30 to 70 feet of pebbly sand, overlain by 0 to 40 feet of clay, overlain by 15 to 40 feet of fine sand. Past interpretations of this section correlated these units with the Jameco Gravel, Gardiners Clay, and Jacob Sand on Long Island. Our work, however, indicates that the Highland Plain deposits represent a wedge of sediments laid down in a ponded body of water dammed by the Wellfleet plain deposits to the south, Cape Cod Bay lobe ice to the north, and the South Channel lobe ice to the east. Surface gradient and pebble counts show the South Channel lobe as the source. The clay interfingers with sand and pinches out at the south end, and appears to have been truncated at the north end. The clay and overlying sand show the lacustrine origin of the unit; however, there is some discussion about the origin of the underlying sand. If the underlying sand is not lacustrine, there are some fundamental problems to resolve.

At the north end of the section is a body of poorly sorted sand, silt, minor clay, and rounded pebbles, which we have called a diamicton. Its origin is unclear, but it probably was not laid down directly by ice as till.

The Truro plain deposits overlie the Highland deposits in unconformable contact, and with a little luck and a lot of muscle, we may be able to see this today.

STOP 2. Parabolic dunes northeast of Pilgrim Lake.

Well-defined parabolic or upsilioid dunes, formed by dominant winds from the northwest, form a continuous series from about 0.7 miles east-southeast of our stop to the Race Point Coast Guard Station about 5.5 miles to the northwest. The best forms extend for about 3 miles. The dunes are composed of fine sand to granules, with some small pebbles (just over 4 mm). Heavy mineral concentrations and grain-size variations emphasize the dune bedding.

One of the puzzling facts encountered in the parabolic dune field is the prevalence of nearly horizontal bedding (0-10°) in the inner parts of the dune. It is not found everywhere, but does occur in enough places to make it evident that the dunes are more complex than they appear to be on a map.

The short walk here will take us onto the crest of the parabolic dune near its contact with the foredune, to which it is attached. The blowout in the center of the dune is less than 10 feet above sea level.

A good view of the inner part of the next dune east may be had from the nose of the first one.

If the Spring wildflowers are in bloom, the resident botanist in the Geological Survey office - Phil Schafer - will be asked to identify them and comment on their ecology.

STOP 3. Fossil beach deposits and modern ventifacts.

The bus will park near the Airport, and we will walk a short distance over the former foredunes into a small valley between dune ridges.

At numerous low spots and blowouts south of the continuous foredune that parallels the ocean one can find lag deposits of pebbles and cobbles, and even, rarely, boulders. These stones are generally rounded to oblong discs overlying clean sand with bedding characteristic of modern beaches. The stones are slightly wind abraded, generally on the upper surface only. Present-day beach pebbles and cobbles are not ventifacted because of constant movement and surf action. But as soon as the stones are undisturbed, the process of wind abrasion begins.

The age of the beaches is not known, but they must date from the time when sea level approached its present level. That is, they must be less than 3500 years old.

STOP 4. Longnook Beaches.

The road leading to Longnook Beach runs along one of the pamets or furrows common to the outwash plains of Cape Cod. The furrows are now dry, and appear to be graded to below present sea level. Collapse features along the valley walls are some of the indications these furrows were cut in late-glacial time. More about these at Stop 5.

LUNCH, either before or after discussion.

The exposures here have exhibited excellent deltaic foresets at least as much as 50 feet, and probably more, above the beach. This is one part of the evidence for the existence of a glacial lake in Cape Cod Bay, dammed by ice to the north and east, the mainland to the west, and the Sandwich moraine to the south.

STOP 5. Pamet River - Ballston Beach.

This pamet is the largest on the Cape. The origin of this valley may differ somewhat from most of the other dry valleys or furrows in that there may have been more dead ice here; hence a wider and deeper valley. How much of the valley is due to erosion or collapse is problematical. In addition, it may have had its source at the glacier, unlike the other furrows.

STOP 6. Bound Brook pit.

This stop will be omitted if the exposure is poor at the time of the trip. The pit is located just northwest of the intersection of the New Haven railroad bed and Bound Brook in Wellfleet. The exposure is stratigraphically in the upper part of the Wellfleet plain deposits and roughly in the middle of the outwash plain. The exposure shows delta foreset overlying clayey silt. Both units are thought to have been deposited in the lake that occupied Cape Cod Bay. Exposures of similar deltaic (?) sand overlying clayey silt occur on Great Island and Great Beach hill on the west side of Wellfleet Harbor. In 1964 and 1965 the exposure here consisted of the following units from the base of the pit to the top: 1) A gray, massive clayey silt containing scattered granules and pebbles. The upper part of this unit was stained brown and iron cemented. The base was not exposed. 2) A few feet of massive brown silty fine to very fine sand, also iron cemented. 3) Above these fine-grained units the section consisted of several tens of feet of deltaic (?) medium to very coarse gravelly sand and minor amounts of granule to cobble gravel. In one lens of granule gravel abundant shell fragments were found. Bedding within the sand consisted of large scale foresets that dipped steeply west.

STOP 7. Newcomb Hollow clayey silt locality.

This exposure is located on the "back side" of the Cape just south of Newcomb Hollow. Newcomb Hollow, along with Bound Brook valley, forms one of the furrows that crosses the Wellfleet outwash plain. The clayey silt is stratigraphically near the top of the older Wellfleet plain deposits. The surface of the plain has been collapsed from 50 to 75 feet in this area. The clayey silt, although highly deformed, is texturally representative of the clayey silt found elsewhere in the older Wellfleet plain deposits. It varies laterally from a massive, poorly sorted, till-like deposit to well-laminated clayey silt, silt, and clay. Angular to subrounded pebbles and cobbles are found in both the till-like and well laminated facies. Boulders are scattered throughout the clayey silt. Shell fragments and carbonized wood fragments are found in some places. In most places, contacts between the clayey silt and the underlying and overlying sand and gravel are sharp. At Great Beach Hill, a lag (?) of pebbles and cobbles occurs along the upper contact and at one place in the North Truro quadrangle a layer of wind-polished stones occurs at the base of a clayey silt layer and over foreset-bedded sand. Although texturally similar, the clayey silt exposed from place to place in the older Wellfleet plain deposits is not considered stratigraphically equivalent. No correlation is made between the clayey silt exposed along the back side of the Cape and exposures along Cape Cod Bay and Wellfleet Harbor, or with the Highland clay at Highland light.

STOP 8. Marconi Station overlook.

The contact between the older and younger Wellfleet plain deposits occurs about one-third the way down the cliff. The contact between the Wellfleet plain deposits and the Eastham plain deposits occurs about 600 feet south of the station. To the west, the scarp between the Wellfleet plain deposits and the Eastham plain can be seen. This scarp is thought to be an ice-contact slope developed when part of the South Channel lobe occupied the site of the Eastham plain deposits. Orleans quadrangle,

Dunes
Eastham
Young cliff
Old Wellfleet

Min. altitude on the Eastham plain occur to the South in the

50' in S, only 50-60' @ Marconi

and the surface of the plain can be seen to rise in that direction. Textures in the three units are similar, and the contacts were defined on the basis of topography and pebble counts.

STOP 9. Kingsbury Beach Road pit.

The location is approximately one-half mile northeast of the intersection of Kingsbury Beach and Herring Brook Roads. We will visit this pit or one of several others that best shows the internal structure of the downstream part of the Eastham plain. All of these pits show scour-and-fill crossbedding, tabular crossbedding, and planar bedding, suggesting that the Eastham plain is fluvial at least to near sea level. The Eastham plain in this area is composed of gravelly sand with minor amounts of pebble to cobble gravel. To the east it becomes much less well sorted and composed of gravelly sand, pebble to boulder gravel, clayey silt, and till. Large boulders on the surface mark this change in texture.

STOP 10. Nauset Coast Guard Station.

The sediments exposed in the sea cliff are in the upper part of the Eastham plain deposits. In 1965 the exposure immediately north of the parking lot showed 10 feet of till, underlain by 2 feet of sand and gravel, underlain by at least 3 feet of laminated silt. Fifteen hundred feet to the north two till layers were exposed,overlain and underlain by sand and gravel. A third exposure 500 feet further north showed five feet of till overlain by sand and gravel and underlain by interbedded sand, gravel, clayey silt, and clay. The till bodies may have been deposited by ice, but are more likely flowtills deposited when the South Channel lobe occupied a position a very short distance to the east. The variability in texture of the Eastham plain deposits and the occurence of maximum surface altitudes on the Eastham plain in this area suggest that the head of outwash was nearby. To the southwest, till bodies and boulders along the shore of Nauset Bay and Salt Pond Bay suggest the close proximity of ice in this area during the deposition of the Eastham plain deposits, possibly a remnant of a larger ice block that occupied the site of the Eastham plain during formation of the Wellfleet plain.

A fabric study from till immediately north of the parking lot showed that the long axes of stones in the till have a preferred plunge direction of about west-southwest.

STOP 11. Enos Rock.

The largest boulder presently known on Cape Cod is Enos Rock, located three-quarters of a mile northeast of Eastham. It is a greenish volcanic boulder about 40 feet long by 25 feet wide. It is at least 27 feet from top to bottom and projects 15 feet above ground level. Holes dug next to

the northwest and southeast corners of the boulder showed unbedded eolian deposits 3 to 6 feet thick underlain by medium to very coarse gravelly fluvial sand. Away from the rock, bedding in the gravelly sand and the contact between the sand and eolian deposits are nearly horizontal, but within a foot or two of the boulder dip steeply toward it at 25 to 50 degrees. The eolian deposits are wedge shaped in cross section normal to the boulder, and the rock is wind polished to at least 5 feet below ground.

STOP 12. Nauset Heights beach. (Please do not climb or dig in the bluff)

The high content of mafic stones in the beach reflects a similar high concentration in the Nauset Heights deposits. This characteristic was used to distinguish the Nauset Heights deposits from the other glacial deposits on Cape Cod. A possible source of the mafic stones is an area of mafic rocks indicated by a magnetic high located about 8 to 10 miles offshore to the northeast. Red arkosic conglomerate occurs in amounts less than 1 percent but is more abundant and occurs in larger fragments than in other glacial deposits. The arkose may have come from a deep valley located in North Truro and filled in part with a material having seismic velocities similar to those recorded on arkosic sediments in the Connecticut Valley.

STOP 13. Barcliff Road pit Chatham.

This pit exposes the upper part of the Harwich outwash plain deposits, which are overlain in the northern part of the pit by brown till up to five feet thick. The till is similar to till that overlies or is interbedded with the Harwich outwash plain and Nauset Heights deposits to the north. Fabric studies in the till here and in several other places showed a preferred northwest orientation. The till is thought to be flowtill derived from ice blocks of the South Channel lobe that in this area were buried by Harwich outwash plain deposits.

The high ground to the west, mapped as the Chatham Kame, is composed of sand and gravel. This deposit, along with several others that project through Cape Cod Bay lobe outwash, includes the oldest glacial deposits exposed at the surface on Cape Cod.

STOP 14. Chatham Light.

Chatham Light is on an inactive sea cliff that has a broad beach capped by dunes at its base. The sea cliff probably ceased being eroded when an offshore bar, which can be seen on the 1887 15-minute quadrangle, developed near the middle of the present Chatham Harbor. The bar was destroyed, probably as a result of increased tidal currents in Chatham Harbor, when Nauset Beach spit built southward. The spit has grown southward as a result of longshore currents, and westward into the lagoon by overwash deposition.

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PRELIMINARY REPORT ON THE GEOLOGY OF THE CAPE COD NATIONAL SEASHORE*#

J. H. Hartshorn, R. N. Oldale, and Carl Koteff

INTRODUCTION

The establishment of the Cape Cod National Seashore (Fig. 1) sets aside for public use and enjoyment a large part of outer Cape Cod from Long Point in Provincetown to the south end of Nauset Beach in Chatham. The scenery is unique and spectacular and is due to the last great continental glacier that overspread southern New England and to the subsequent rise of sea level and the resulting marine erosion.

The New England Branch of the U.S. Geological Survey has long had the Cape Cod area as one of its major targets in making quadrangle maps of the Pleistocene geology of the Commonwealth of Massachusetts. When the National Seashore was proposed, the Geological Survey undertook to map the park and to prepare both professional maps and a brochure on points of geologic interest for visitors to the park.

The three authors worked as a team in the field. R. N. Oldale mapped the geology in the Wellfleet, Orleans, Chatham, and Harwich quadrangles; Carl Koteff mapped the North Truro and Monomoy Point quadrangles (the latter south of the Chatham quadrangle); and J. H. Hartshorn mapped the Provincetown quadrangle and prepared this paper. Rachel Barker is working on a brochure.

Cape Cod is composed of a thick series of glacial deposits. The inner Cape, formed by deposition from the Buzzards Bay ice lobe to the west and the Cape Cod Bay lobe to the north, is composed of the Sandwich and Buzzards Bay moraines and associated promorainal outwash deposits. The outer Cape was formed in an interlobate area between two ice lobes, the South Channel lobe on the east and the Cape Cod Bay lobe on the west. A series of outwash deposits--the Wellfleet, Highland, Truro, and Eastham plains-- were laid down by melt waters from the South Channel lobe. The rising sea eroded the glacial deposits and formed Monomoy Island south of Chatham, Nauset Beach, and Provincetown hook. The northernmost glacial deposits on Cape Cod are at High Head.

PRE-PLEISTOCENE GEOLOGY

The lithology of the basement rocks beneath the outer Cape is unknown. Two drill holes in Brewster and one in Harwich, each about 1,000 feet deep, reached bedrock. The Harwich hole showed light-gray phyllite (Koteff and Cotton, 1962); the Brewster holes showed gneissic and porphyritic granite. In addition, aeromagnetic data indicate the presence of other rock types. A comparison of seismic data in Brewster and Harwich with seismic data on the outer Cape suggests that similar rocks may form the basement in both areas (Oldale and Tuttle, 1964).

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In cooperation with the Massachusetts Department of Public Works.

Depth to basement is about 350 feet at Orleans and about 500 feet at Provincetown (Oldale and Tuttle, 1964) and ranges between these two depths throughout most of outer Cape Cod. A maximum depth occurs between Provincetown and North Truro, where a buried valley cut into the basement reaches a depth of approximately 900 feet below sea level. Seismic data suggest that the deep valley in the basement may be partly filled with deposits of Mesozoic age, possibly Cretaceous.

Eocene sediments are reported (Zeigler and others, 1960) at depths ranging from nearly sea level to 230 feet below sea level beneath Pleistocene and Recent deposits at High Head and Provincetown.

PLEISTOCENE GEOLOGY

Inner Cape Cod. Compact, gray, silty and bouldery tills were found in four drill holes in Harwich and Brewster; they range in thickness from 20 to more than 100 feet. The tills directly overlie the basement rocks. Compressional-wave velocities measured in the till at Harwich are similar to velocities measured on the subglacial drumlin tills in northeastern Massachusetts; the tills may therefore be subglacial in origin (Oldale and Tuttle, 1965). Till as much as 375 feet thick occurs in a deep valley in the basement near the west boundary of the Harwich quadrangle. Minimum recorded thicknesses occur on the north side of the Cape near Brewster.

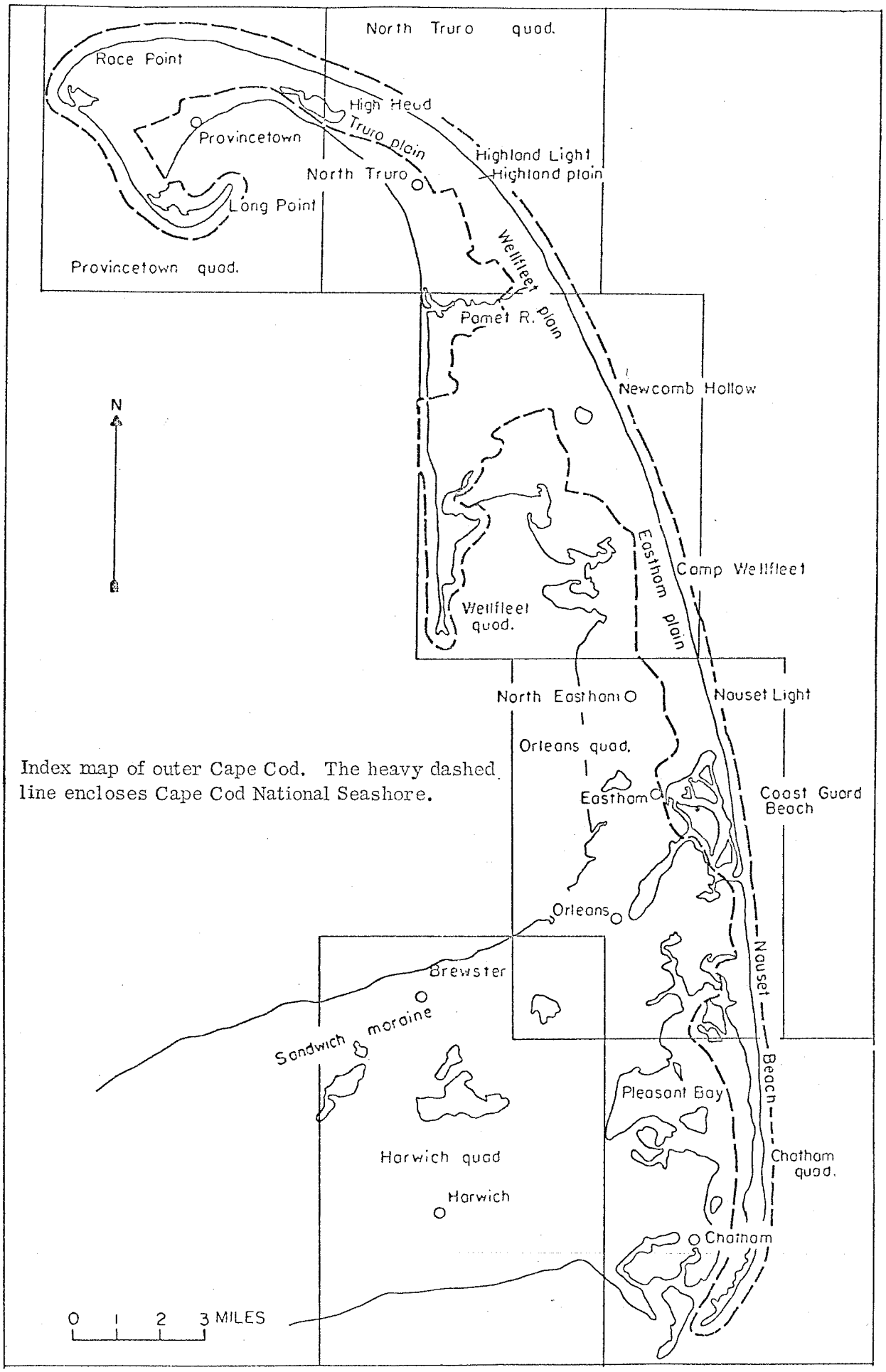
The Sandwich moraine, which is composed primarily of stratified drift and some till, is best developed in western Cape Cod; it decreases in height and is less well defined just west of the Harwich quadrangle. The till ranges from gray, sandy, and stony to brown, silty, and less stony. Boulders are abundant on the moraine in most places. Much of the easternmost Sandwich moraine is probably an area of stratified drift deposited on the irregular outer margin of the glacier and later let down by collapse. Numerous kettle holes in the moraine attest to the presence of blocks of ice during the deposition of the sediments.

The upper part of the outwash in front of the Sandwich moraine is composed of extensively collapsed glaciofluvial sand and gravel with many dry or water-filled kettle holes and numerous ice-contact slopes. At the south end of the outwash, boulders are not nearly as abundant, and clay is found in scattered outcrops.

Outer Cape Cod. The most prominent features of outer Cape Cod are the extensive westerly sloping surfaces of sand and gravel called the Truro, Wellfleet, and Eastham plains by Grabau (1897) and the Highland plain by Wilson (1906, p. 55). The flat parts of the plains are interrupted by areas of collapse and by erosional valleys and are truncated on the east and west sides by marine erosion.

The deposits in the four plains are generally similar and consist mostly of sand, with minor clay or silt-clay units. Distinctions between the major geologic map units are made on the basis of topography, structure, grain size, and pebble counts.

Figure 1.



Index map of outer Cape Cod. The heavy dashed line encloses Cape Cod National Seashore.

The presence of a great many kettle holes shows that at one time the glacier covered all of Cape Cod. The ice blocks may have been completely buried or, as indicated by large boulders on the surface near the kettles, may have extended above the deposits as hills of ice. In some places, sea-cliff erosion has exposed cross sections of kettles. Faulting and folding related to the formation of the kettles can be traced as far down as sea level; thus some of the buried ice was below sea level. This is also indicated by the depth of some of the fresh-water ponds in the kettles.

Erosional valleys in the plains are relatively straight; most are narrow and generally steep walled. The heads of some valleys terminate in the plains; other valleys extend completely across the outer Cape. Their gradients, where determined in the Wellfleet plain, are 38 to 87 feet per mile, almost four times the gradient of the surface in which they are cut. Kettle holes that interrupt the gradients of the valley bottoms prove that the valleys were cut before the ice blocks completely melted out. This indicates that the valleys were cut during late-glacial times, but other evidence shows that the eroding streams started out on the plains and did not come from the glacier. The valleys are graded to a base level below present sea level, as shown by some with drowned mouths.

North of North Eastham boulders are uncommon in and on the drift. To the south, boulders are numerous. The largest boulder known is Enos Rock (also called Doane Rock) three-quarters of a mile northeast of Eastham; it is a greenish volcanic rock about 40 feet long by 25 feet wide by 15 feet high and is sitting in collapsed stratified drift.

Wellfleet plain deposits. The Wellfleet plain is the oldest, highest, and most extensive of the plains, with elevations of as much as 155 feet on the eastern side and about 60 to 100 feet on the western side. It has an average gradient of about 20 feet to the mile to the southwest, as reconstructed from uncollapsed and uneroded interfluve areas. The largest erosional valleys and large kettle holes occur in this plain.

Between Pamet River and Newcomb Hollow the lowest visible unit is a medium to very coarse grained sand with scattered granules, pebbles, and cobbles. Above this is a massive to well bedded gray clayey silt that contains scattered sand grains, granules, cobbles, and isolated boulders. The top and bottom of this unit usually are oxidized brown by ground water, and the upper contact is marked by a sharp change to clean, medium to coarse sand containing scattered granules, pebbles, and cobbles. In places, a second clayey silt layer, generally interbedded with very fine sand, occurs a short interval above the lower clay; the bedding is commonly contorted. The upper contact of the clay is sharply defined and is overlain by 50 to 100 feet of interbedded fine to very coarse sand that contains scattered granules, pebbles, and cobbles, a few pebble to cobble gravel beds, and a few boulders. The bedding includes flat-bedded, crossbedded, and current-rippled beds, cut-and-fill structures, and deltaic foreset beds.

Well-developed deltaic foreset beds occur at several places in the western part of the Wellfleet quadrangle. The altitude of the top of the foresets is not known, but the foresets are at least 70 feet above present sea level and overlie clay and silt.

Highland plain deposits. The Highland plain occupies a small triangular area between the slightly higher Wellfleet plain and the lower Truro plain. It is over 120 feet above sea level on the eastern side and slopes gently westward.

The best known stratigraphic section of outer Cape Cod is at Highland Light (Woodworth and Wigglesworth, 1934). The base of the section consists of iron-stained coarse sand to pebble and cobble gravel. Above this is an 1800-foot-long exposure of gray clay and silty clay, as much as 45 feet thick. The north end of the lens of clay is truncated by erosion; the south end interfingers laterally with sand. The upper surface of the clay is contorted into rolls and clastic dikes, which penetrate the overlying sand. Deformed bedding also occurs in the main body of the clay. The top of the section is composed of as much as 35 feet of yellowish-gray, fine- to medium-grained, ripple-laminated sand.

Truro plain deposits. The Truro plain is the northernmost of the four plains, slopes more gently to the west than the Wellfleet plain, and ranges from about 70 feet above sea level on the northeast to about 50 feet on the southwest side. It is less modified by collapse and erosion than the other plains. About 2000 feet north of Highland Light the Truro plain deposits overlie the Highland plain deposits with unconformable contact. The unconformity has a gentle northwesterly slope and truncates beds in the Highland plain deposits.

The Truro plain deposits consist chiefly of fine-grained, yellowish-gray, flat-bedded, ripple-laminated sand with scattered pebbles and cobbles; they resemble the upper part of the deposits of Highland Light. Near the unconformity, blocks of flat-bedded, fine-grained silt, possibly derived from the Highland plain deposits, are found in vertical positions. In some places, steeply dipping deltaic foresets occur in the Truro plain deposits.

Eastham plain deposits. The Eastham plain is similar in many respects to the Truro plain; it has a low gradient and less modification by dry valleys. The southern part of the plain is extensively kettled with numerous, closely spaced, shallow depressions.

The contact between the Wellfleet plain deposits and the Eastham plain deposits, although not well known, is believed to be at the north end of a heavily kettled area 1.5 miles south of Newcomb Hollow. Pebble counts and topographic studies indicate that the Eastham plain is not traceable into the lower part of the Wellfleet plain deposits and lies stratigraphically above the Wellfleet plain deposits.

At Camp Wellfleet, the Eastham plain deposits exposed in the cliff are composed of yellowish-gray, flat-bedded and crossbedded, fine to very coarse sand with scattered pebbles and cobbles, and a few gravel beds.

South of the Camp Wellfleet section, the Eastham plain deposits appear to be coarser grained and more poorly sorted. In the highly collapsed part of the Eastham plain, from Nauset Light south, till or till-like material occurs at several horizons in the section. The till is brown, hard, silty to sandy, and has a matrix that contains scattered pebbles, cobbles, and boulders.

After a northeast storm in the fall of 1964, a dark-brown, very hard, stony till with a silty matrix was exposed in the low sea cliff and in broken blocks in the beach sand at Coast Guard Beach, Eastham. Wave action had etched the till and revealed thin bedding and laminations. The low cliffs north of the beach show highly collapsed sand and gravel with fluvial bedding and some layers of brown till.

Chatham-Orleans area. South and east of the Eastham plain deposits, outwash deposited from the South Channel lobe occurs as far south as Pleasant Bay. Deposits in the Chatham quadrangle are composed mostly of outwash in front of the Sandwich moraine and derived from the Cape Cod Bay lobe. A till or till-like body caps these outwash deposits in places.

Fossils. Fossiliferous cobbles of Eocene sandstone, fragments of probably Cretaceous or Tertiary silicified wood, sharks' (?) teeth, and carbonized wood fragments occur in the deposits. Radiocarbon dates on the wood range from 26,000 ± 1,000 (W-1585; measurements by Isotope Laboratory, U. S. Geological Survey) to greater than 42,000 (W-1581) years B. P.

Complete valves and shell fragments of pelecypods and gastropods occur in all units of the Wellfleet, Highland, and Truro plain deposits except the clay deposits at Highland Light. The shell fragments range in age from 20,700 ± 2,000 (Zeigler and others, 1964) to greater than 32,000 (W-1583) years B. P. The shells are not in position of growth and were probably transported from marine deposits overridden by the ice sheet.

Shell fragments have not been found in the Eastham plain deposits and are fewer in the Truro plain deposits than in the Wellfleet and Highland plain deposits. No radiocarbon dates on shells have been obtained from the Truro plain deposits.

RECENT GEOLOGY

Marine erosion. The beaches are derived solely from the glacial deposits that make up the higher lands of Cape Cod because the surrounding water is too deep to allow replenishment from outside the Cape. The beach material is carried both north and south along the east shore from a dividing line somewhere near the center of the outer Cape.

The cliffs that surround Cape Cod are the products of marine erosion. Most of the erosion takes place during winter storms; an average of about 3 feet per year is quoted for the eastern side of the Cape (J. M. Zeigler, personal communication, 1964). Less severe erosion takes place on the west side, but some high cliffs are present there as well. The large quantities of sand in Provincetown hook, Nauset Beach, Monomoy Island south of Chatham, and other numerous spits, bars, and beaches indicate the amount of erosion that has taken place since sea level reached the glacial deposits.

The strength of the coastal currents is indicated by small discoidal boulders, about 10 inches in longest dimension, carried to the outermost parts of the Cape--Monomoy Point and Long Point.

Wind deposits. Foredunes, the first and outermost dunes raised from the beaches by the wind, are generally long and linear and parallel to the coastline. They are best developed along the outer shore of Cape Cod, in particular along Nauset Beach and from 3/4 mile north of Highland Light northward around to Race Point. On the west side of the outer Cape, foredunes are well developed but discontinuous.

The surface of a foredune is hummocky; bedding in the dunes, where visible, is commonly flat or gently inclined inland. The seaward edge of the dune is generally cliffed and the bedding is easily visible.

The construction of the Provincetown hook as a coalescent series of beaches provided both a source and a base for several generations of parabolic dunes. The parabolic dunes include both U-shaped and V-shaped dunes with the open ends toward the west-northwest wind. The sand is fine to coarse grained, with numerous areas of granules and some small pebbles. Concentrations of heavy minerals appear on the sloping dune surfaces as dark patches and are conspicuous especially where the surface is rippled. Several sets of parabolic dunes are present. Those near Provincetown have a more southerly orientation than those along the northern shore of the peninsula, although the difference is not great.

The central part of the Provincetown hook is occupied by large dunes that are as much as 105 feet high and not recognizably parabolic. The sand is fine to coarse grained, with some granules in areas of strongest wind concentration. The direction of the wind that built these large dunes is uncertain, but the dominant winds probably were from the same west-northwest direction indicated by the orientation of the parabolic dunes. The common occurrence of forms gradational between this type of dune and the parabolic dunes suggests that the large dunes may have originated as parabolic dunes.

Windblown sand deposits not mapped as particular dune forms are classified as undifferentiated eolian deposits. Some of these deposits are in the low areas between dunes or are small irregular dunes. Included elsewhere are clifftop dunes and climbing dunes that are formed by beach sand blown up the cliffs.

Nearly all of the glacial deposits are overlain by a general blanket of medium to fine sand and some silt deposited by late-glacial winds blowing over nearly bare sand areas. This eolian layer is a few inches to a few feet thick, is oxidized to a yellowish brown, is slightly coherent, and contains numerous stones, among which are many ventifacts. This unstratified, stony sand has been misidentified as till by earlier workers on the Cape.

Sand dunes, with little or no visible oxidation, lie on the eolian deposits and, with the active beaches, are the youngest postglacial feature on the glacial deposits.

Ventifacts. Wind-polished and wind-abraded stones are extremely common on Cape Cod. They are characterized by pits and flutes that in places emphasize the texture of the rock and by a surface that is generally highly polished. Ventifacts are most common in the eolian layer, but in some places are well down in the glacial deposits. Beaches that have not been overrun by the sea for at least several decades also have many ventifacts on the surface. Many of the large boulders on the beaches and on the glacial deposits are excellent ventifacts. A few stones show the classic dreikanter shape.

Soils. The podzol is a prominent feature of soil development on outer Cape Cod. Its outstanding and most characteristic feature is the development of an ashy-gray to nearly white zone just below the black of the organic upper layer. The light zone spreads out downslope on cuts and appears to be more extensive than it really is. Below this is a zone that has a strong reddish-brown color. This zone accounts for most of the bright colors found in the slump along slopes.

PLEISTOCENE HISTORY

Although multiple advances of the Pleistocene glaciers have been recognized on Martha's Vineyard (Kaye, 1964) and in the Boston area (Kaye, 1961), the evidence on outer Cape Cod suggests that all the deposits were the result of the latest major ice advance in New England. The till found in the Brewster and Harwich drill holes may be the basal till of this advance. Seismic data, borehole data, and the numerous kettle holes that go below sea level all suggest that the sections exposed in the sea cliffs represent the retreatal deposits of a single glaciation. Radiocarbon dates indicate that the last advance over outer Cape Cod took place at least 20,000 to 26,000 years B. P.

The last ice sheet advanced at least as far as the northern shores of Martha's Vineyard and Nantucket. A radiocarbon date from Martha's Vineyard (Kaye, 1964) suggests that this ice sheet began to retreat more than 15,000 years ago. When the glacier had retreated to a position along the north shore of inner Cape Cod, it remained long enough to build the Sandwich moraine and a large outwash plain with an ice-contact head.

Continued retreat opened up an interlobate area larger than the present outer Cape. The exact configurations of the ice fronts are not known, but ice of the South Channel lobe stood to the east. The gradients of the plains, the bedding of the deposits, and a comparison of pebble counts from the deposits of outer Cape Cod with those of western Cape Cod indicate that the glacial sediments of the outer Cape were derived from the ice of the South Channel lobe. These sediments were deposited as proglacial outwash plains over and around numerous ice blocks and as lacustrine sediments, some of which are deltaic.

The boundaries between the Eastham and Wellfleet plains are not clearly marked, but the Wellfleet plain is older because it is higher and because the Eastham plain deposits do not extend below the Wellfleet plain deposits. The Truro plain deposits are younger than the Highland plain deposits, as shown north of Highland Light where the Truro deposits are lower and overlie the sloping unconformity of the Highland deposits. The Highland deposits in turn are younger than the Wellfleet deposits.

RECENT HISTORY

During glacial maxima, eustatic sea level was lowered approximately 300 feet below present sea level. However, as sea level rose after the retreat of the ice, marine erosion began to affect the Cape Cod deposits, of which only some now remain.

As the cliffs were eroded, marine beaches, bars, and spits formed along both the east and west coasts of Cape Cod. Wind action lifted the sand above the beaches and built extensive foredunes. In the Provincetown area the foredunes moved inland as the coast built outward, and parabolic and massive dunes rose to heights of at least 100 feet above sea level. Extensive salt marshes formed in sheltered bays and coves.

dinner 4.50
Box lunch 1.25
Bus + redfst 6.00
$11.75

sent May 1 '68
w/ check # 623 for $11.75

FRIENDS OF THE PLEISTOCENE
31st Annual Reunion

May 24-26, 1968

Cape Cod, Massachusetts

Second and final announcement

Headquarters and accomodations:

Headquarters will be at the Seashore Park Motor Inn, Orleans, Massachusetts, and Friends should check in there Friday afternoon or evening, May 24. The motel is a large one, but because of the indicated heavy response there will be some spillover into nearby motels (all within a few minutes walk of each other). No advance reservation beyond the answer to this announcement is necessary. Rooms will be at a standard rate of $6.00 per night per person, and can be paid for individually on arrival. There are two double beds to each room. If you have particular roommate preferences, let us know - otherwise we'll assign rooms impartially as you arrive.

How to get there:

Follow U. S. Route 6 (the Mid-Cape Highway) to the traffic circle at the Orleans-Eastham town line (Exit 13) which is the junction with state route 28. The Seashore Park Motor Inn is located just off the circle. Route 6 travels along a good bit of the Sandwich moraine. A pleasant, if longer, trip is along route 6a. For those coming by air, the airport at Hyannis is served by Northeast Airlines.

Transportation and meals:

We will use busses for Saturday and Sunday; no private cars will be allowed. The annual dinner will be at the Orleans Inn Saturday night. Options are roast beef or baked stuffed shrimp, either for $4.50. Lunch on Saturday will be supplied for $1.25 to those who want it. The Orleans Inn (a few minutes from the motels) has a Friday night buffet which is reputed to be very good. There are a few other restaurants in Orleans and Chatham, although it is not certain what their off-season schedule is. The motel supplies a breakfast "just short of ham and eggs" according to the manager. A pancake house nearby will be open both mornings as well. We plan to break up the trip around noon on Sunday, so everyone will have to fend for themselves then. Either bring your own lunch, or the ingredients, or plan to eat at one of the many good restaurants near Hyannis.

A caution:

Rocky Mountain Spotted Fever, carried by ticks, has been reported on the Cape in the past year, resulting in a few fatalities. You may wish to get shots for this - at any rate, a nightly check for ticks is advised. We

will be walking a lot on beach or dune sand, so judge your footwear accordingly. The Cape can be quite cool at this time of year, so be prepared with some warm clothing.

Other:

The Park Service has indicated that there will be a program for those interested at the Visitor's Center in Eastham Friday evening.

Maps and references:

Because of the large volume anticipated, we have decided not to handle publications ourselves. Topographic maps covering the area are: Provincetown, North Truro, Wellfleet, Orleans, Chatham, and Harwich 7 1/2' quadrangles, 1:24,000 scale. The "Geologic map of the North Truro quadrangle, Barnstable County, Massachusetts: U. S. Geological Survey Geol. Quad. GQ-599" was published in 1967 and may be of interest. The topo maps, for 50 cents each, and the GQ, at $1.00, can be ordered from:

Distribution Section
U. S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

Two references of general interest are:

Woodworth, J. B., and Wigglesworth, Edward, 1934, Geography and Geology of the region including Cape Cod, the Elizabeth Islands, Nantucket, Martha's Vineyard, No Mans Land, and Block Island: Harvard Coll. Mus. Comp. Zoology Mem., v. 52, 338 p.

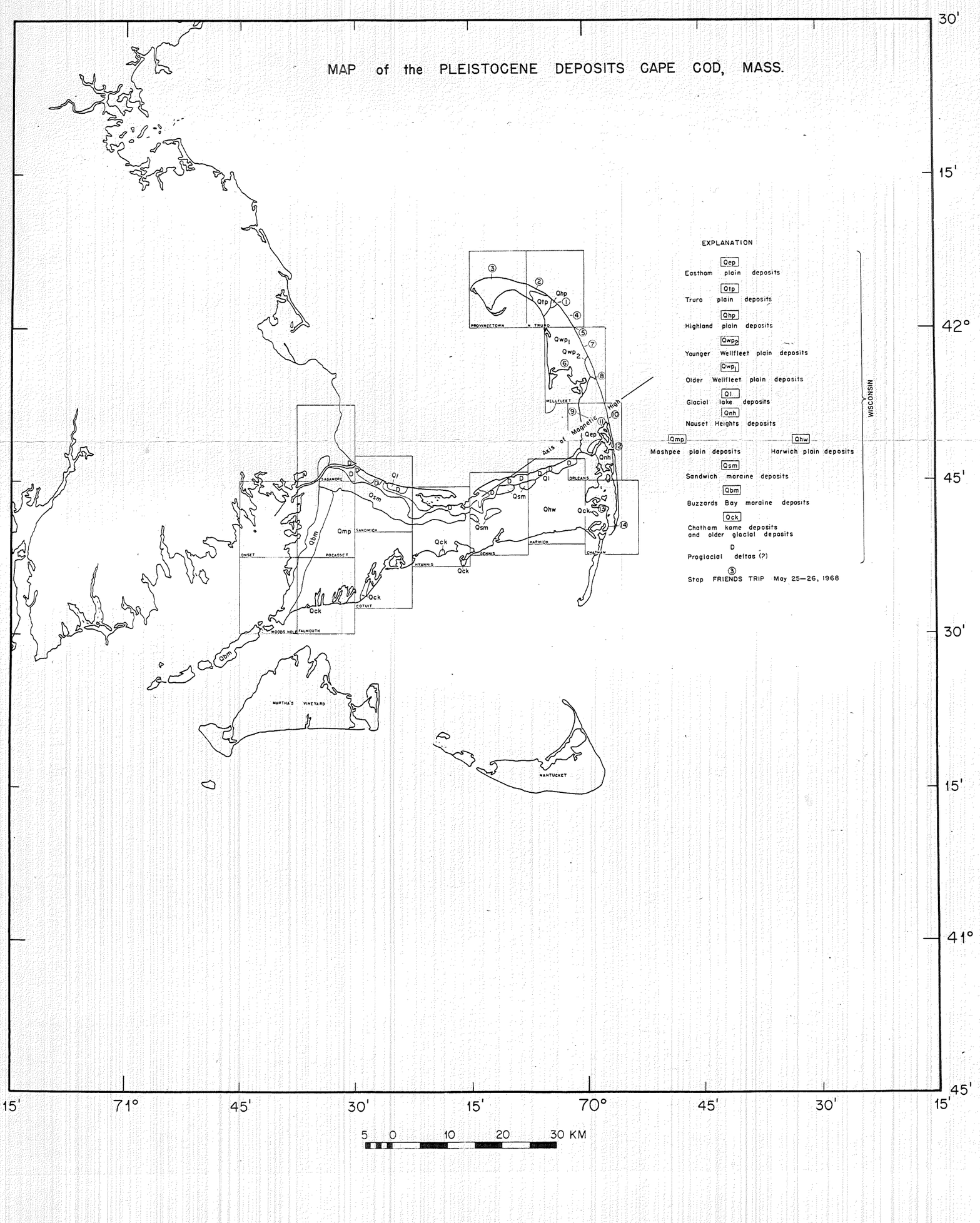
Zeigler, J. M., Tuttle, S. D., Tasha, H. J., and Giese, G. S., 1964, Pleistocene geology of outer Cape Cod, Massachusetts: Geol. Soc. America Bull., v. 75, p. 705-714.

What we'll see:

Planned are stops in the Provincetown dunes, including a fossil beach deposit, and exposures on the wave-cut cliffs of the Truro, Highland, Wellfleet, and Eastham Plains. Other stops will be in and around Chatham. After the trip breaks up around Sunday noon, we will be glad to visit the Sandwich moraine to the west in the Dennis and Hyannis quadrangles with anyone that is interested.

Joe, Bob, and I are looking forward to seeing you.

Carl Koteff


MAP of the PLEISTOCENE DEPOSITS CAPE COD, MASS.
EXPLANATION
Qep
Eastham plain deposits
Qtp
Truro plain deposits
Qhp
Highland plain deposits
Qwp2
Younger Wellfleet plain deposits
Qwp1
Older Wellfleet plain deposits
Ql
Glacial lake deposits
Qnh
Nauset Heights deposits
Qmp
Mashpee plain deposits
Qhw
Harwich plain deposits
Qsm
Sandwich moraine deposits
Qbm
Buzzards Bay moraine deposits
Qck
Chatham kame deposits and older glacial deposits
D
Proglacial deltas (?)
Stop FRIENDS TRIP May 25–26, 1968
WISCONSIN
Axis of Magnetic High
PROVINCETOWN
N. TRURO
WELLFLEET
ORLEANS
CHATHAM
BREWSTER
HARWICH
DENNIS
HYANNIS
SANDWICH
POCASSET
ONSET
COTUIT
FALMOUTH
WOODS HOLE
MARTHA'S VINEYARD
NANTUCKET
71°
70°
42°
41°
15'
30'
45'
5 0 10 20 30 KM

FRIDAY, MAY 31, 1968 The New York Times C 31

Friends of the Pleistocene, geologists who describe themselves as a scientific "nonorganization," gather on a Cape Cod dune to verify a recent thesis on the Cape's formation

Geologists Say Outer Cape Cod Was Once a Lake Bottom

By WALTER SULLIVAN

Like an outstretched, beckoning arm, the outer portion of Cape Cod reaches into the Atlantic, a picturesque haven for summer visitors and a challenge to geologists.

Generations of ice-age specialists have sought in its headlands, dry valleys or "pamets" and kettlehole ponds, clues to how the Outer Cape was formed. Beginning in 1964, following the designation of the Outer Cape as the Cape Cod National Seashore, the United States Geological Survey has sought to formulate a definitive answer for future visitors.

Three of its men studied and have now mapped the Outer Cape. Last weekend more than 100 specialists from as far away as Canada and Wisconsin gathered in Orleans on Cape Cod to assess the results. Ohio State University sent 15 in a twin-engined plane.

The occasion was the annual meeting of a group of geologists that prides itself on being a special kind of scientific "nonorganization." That was how Dr. Richard F. Flint of Yale described the Friends of the Pleistocene as they sat down to dine after tramping over much of the Outer Cape, retreats by ice sheets.

The Pleistocene, which goes back several hundred thousand years as the most recent geologic period, was marked by a succession of advances.

Dr. Flint, a professor of geology, played a central role in forming the Friends of the Pleistocene 31 years ago. The group has no officers, no dues and no publications. Its chapters in the East, Middle West and West simply gather once a year to examine some region of special significance with regard to ice age history.

The geologists who have mapped the Outer Cape are Dr. Joseph H. Hartshorn, now at the University of Massachusetts; Karl Koteff, who is still with the Geological Survey, and Robert Oldale, now at the Woods Hole Oceanographic Institution.

Their thesis is that a large portion of the Outer Cape was laid down on the floor of a huge glacial lake. It covered what is now Cape Cod Bay, as well as most of the Outer Cape, and was formed as the last ice sheet retreated.

By measuring the radioactive carbon content of shells, bits of wood and other material associated with the advance and retreat of the ice sheet, it has been determined that the ice crept south, across the cape, about 20,000 years ago. Its farthest advance is marked by moraines, or ridges of sand, gravel and boulders, along the northern rims of Nantucket and Martha's Vineyard.

The moraines are formed of material that was bulldozed, or carried, by the ice as it moved south. Then, about 15,300 years ago, the ice sheet began to melt. The inland part of the sheet fell back rapidly, but the offshore portion, being at a lower level, continued to be fed by ice flowing from the north. Because much of the world's water was part of the ice sheets, sea levels were at least 200 feet lower and the offshore ice rested on dry land.

It was during this period that a great lake is believed to have formed, enclosed by retreating ice to the north, the offshore ice to the east, the mainland to the west and moraines to the south. The moraines were formed when the ice, in its retreat, paused on what is now the inner, east-west portion of Cape Cod.

Further retreat of the ice allowed the lake to drain into the Atlantic and by 14,000 years ago, the ice had fallen back as far as Lynn, north of Boston.

During the melting phase of the ice age, water flowing away from the retreating ice cliffs carried with it great amounts of sand, gravel and silt, picked up by the glacier during its long journey south. It is of such material that the Outer Cape—virtually devoid of boulders—was formed.

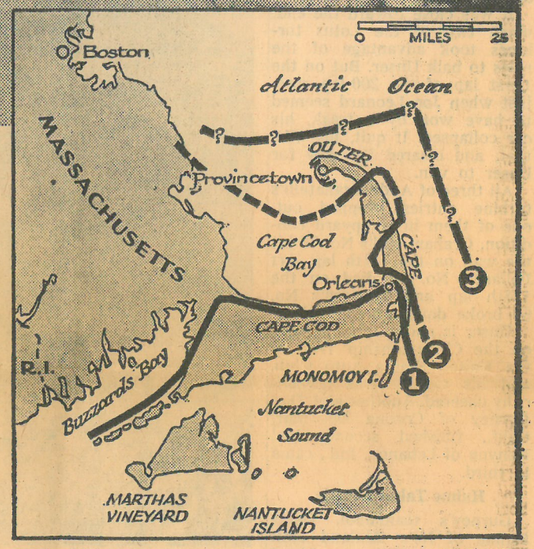
The thesis advanced last weekend was that much of this material was laid down, in delta fashion, along the shore of the hypothetical lake. As the Cape Cod visitors scrambled over bluffs facing the Atlantic, the three geologists who had studied the formations identified a succession of layers of sand, gravel and silt 70 feet thick that, they said, were laid down in this fashion.

The three geologists estimate that the seaward face of the Outer Cape is being worn away by wind and wave at roughly three feet a year. It is estimated that some three miles of terrain have been eroded both from its seaward side and from the bay side. They cited this to explain the peculiar dry valleys, or "pamets," that traverse the cape.

They believe that these furrows were formed when the cape was three times wider.

Wave action has spread sand eroded from the bluffs in both directions along the shore, forming the dunes at the cape's extremity, where Provincetown lies, and the long sandbar of Monomoy Island in the opposite direction.

The process goes on constantly and, as one part of the cape is worn away, other parts are extended, so that maps of the area a decade old are already out of date.



The New York Times May 31, 1968

Geologists suggest that retreat of the last ice sheet to invade North America left ridges of rocky debris along Line 1 and then formed a lake in what is now Cape Cod Bay when it receded to Line 2. A further retreat to Line 3 is believed to have allowed the lake to drain into ocean.

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The New York Times (by Walter Sullivan)

Ice Age specialists dig into the subject . . . literally. They study the layers of sand, gravel and silt to confirm proposal advanced by geologists.