

THE CHARLESTOWN MORaine AND THE RETREAT OF
THE LAST ICE SHEET IN SOUTHERN
RHODE ISLAND

Itinerary for the
FRIENDS OF THE PLEISTOCENE
25th Annual Reunion
May 19 and 20, 1962
Kingston, Rhode Island

by

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SCHEDULE OF THE REUNION

Friday, May 18.

Check in, pick up maps, and meet your Friends: 7-11 p.m., West Room of Memorial Union, University of Rhode Island, Kingston.

Saturday, May 19.

7:00 a.m. - Butterfield Hall, University of Rhode Island, opens for breakfast.

8:00 - Buses leave from south end of parking lot, Keaney Gymnasium, University of Rhode Island. This is just west of the campus, on the north side of Rte. 138 at the foot of the hill. Plenty of room for parking.

12:30 p.m. - Lunch stop at Galilee, Restaurants:
Bus 1: George's
Bus 2: The Port Side

4:30-4:45 - Return to parking lot, Keaney Gymnasium.

6:00 - Annual dinner, Butterfield Hall. A brief meeting will follow the dinner.

Sunday, May 20.

8:00 a.m. - Butterfield Hall opens for breakfast.

9:00 - Buses leave from Keaney Gymnasium parking lot.

12:30 p.m. - Buses return to starting point; official end of trip. Optional excursion for part of afternoon will be in private cars.

Room accommodations:

1. Browning Hall, University of Rhode Island, Kingston.
2. Larchwood Inn, U.S. 1, west part of Wakefield.
3. Neptune Motel, on waterfront south of business center, Narragansett Pier.
4. Narragansett Motel, U.S. 1, half a mile south of Bridgetown Road (Rte. 138).

REFERENCES

- 1) Kaye, C. A., 1960, Surficial geology of the Kingston quadrangle: U. S. Geological Survey Bull. 1071-I, p. 341-396. Price \$1.50.
- 2) Schafer, J. P., 1961, Surficial geology of the Narragansett Pier quadrangle: U. S. Geol. Survey Geol. Quad, Map GQ-140. Price \$1.
- 3) Schafer, J. P., 1961, Surficial geology of the Wickford quadrangle: U. S. Geol. Survey Geol. Quad, Map GQ-136. Price \$1.
- 4) Power, W. R., Jr., 1957, Surficial geology of the Slocum quadrangle, Rhode Island: U. S. Geol. Survey Geol. Quad. Map GQ-106. Price \$1.

(Older publications are cited in these references,)

ITINERARY

SATURDAY, MAY 19.

8:00 a.m. - Buses leave Keaney Gymnasium parking lot.

EN ROUTE TO STOP 1.

Road is on outwash plain that appears to head at small moraine that crosses the valley of the Chipuxet River in the Slocum quadrangle, just north of the Kingston quadrangle. South from Rte. 139, Ministerial Road crosses the deltaic front of this outwash plain where it built out into Glacial Lake Worden, a glacial lake dammed in part by the Charlestown moraine, which is to our south here. Most of the area of Glacial Lake Worden is now occupied by a large swamp, the Great Swamp, famous as the place where King Philip and his Indians were finally defeated by the colonists in 1675.

The road climbs a till-mantled rock knob, Tobey Neck, that rises from the swamp, and then crosses several patches of outwash gravel lying just north of the Charlestown moraine.

STOP 1. Ministerial Road at north edge of moraine (482,950 ft., 123,000 ft.)*, (10 minutes).

*State plane-coordinates. These can be used for locating the site on the topographic map. Tick marks are on margins of the 1:24,000 scale maps. First coordinate is east coordinate, second is north coordinate.

View of Charlestown moraine from the north. The moraine rises abruptly with a steep north slope. This slope is the north side of a ridge-like feature (look back at it as we travel into the moraine) that parallels the trend of the moraine. Though not shown as such on the geologic map (Kaye, 1960), it probably should be classified as a colluvial rampart, that is, a talus that accumulated against the north side of the ice core that underlay the Charlestown moraine after ice to the north had disappeared (to be discussed in more detail under Stop 3). The moraine is 1.4 miles wide (north-south) here, which is close to its maximum width. We are about 1.5 miles from its eastern end.

EN ROUTE TO STOP 2.

As we cross the moraine, notice the ridges and hills on both sides of the road. Seen from the air many of the ridges are sinuous to angular in plan, and the hills, or mounds, are oval to subround. A striking feature of the mounds is that they have flat tops commonly surrounded by a low rim. Just right of the road is Broad Hill, one of the best formed of the rimmed mounds. These are called ice-block casts (Kaye, 1960) and are thought to represent sediment that accumulated in depressions in the ice core that underlay the moraine during its formative years. These holes were caused by the more rapid melting of some blocks of ice, in comparison to the rate of melting of the surrounding ice.

The road descends to the sloping plain south of the moraine. We then go east along the south edge of the moraine and the north edge of the outwash plain that heads up to it, on Post Road (U.S. 1); then south on Matunuck Beach Road.

STOP 2. Hilltop south of Matunuck School (485,850 ft., 110,000 ft.), (40 minutes).

This gives us a general view of the Charlestown moraine and the terrain to the south and east of it.

South of the moraine, a surface of low relief grades gently south to sea level. This sloping plain consists of broad coalescing fans of outwash that originated at the ice front of the Charlestown moraine. Projecting through the outwash in several places, including the site of Stop 2, are low elliptical till-mantled hills (drumlins?) and a few patches of ground moraine that were not buried by outwash.

The till south of the Charlestown moraine seems to have about the same composition and degree of oxidation and soil development as the till in the moraine and north of the moraine. For these reasons, it may be about the same age as the moraine. Unfortunately the few exposures of this till that were studied in 1954 are now badly obscured and no stops are scheduled to examine this unit.

The Charlestown moraine is largely made up of ridges and mounds. The ridges, generally sharply sinuous to curved in plan, range from 5 ft. to 100 ft. in height and from the pattern they inscribe on the map (Kaye, 1960) appear to be crevasse or ice-fracture fillings.* The mounds have about the

*("Ice-fracture filling" is preferable to "crevasse-filling" as a term here because to some, "crevasse" denotes a dynamically formed fracture. The fractures indicated, on the other hand, do not have the pattern or the orientation of the typical crevasse fractures resulting from ice movement. They seem to suggest tension(?) fractures that might, for example, form in massive stagnant ice because of stresses brought on by unequal melting. This problem would be worth discussing here.)

same range in height as the ridges and commonly have a flat top rimmed with a low ridge which also reflects a crevasse, or ice-fracture filling origin. It is suggested that these mounds represent sedimentation in holes in the ice. The holes resulted from the more rapid melting of blocks of ice isolated by fractures and the rimmed tops reflect these marginal fractures by a topographic inversion (Kaye, 1960, Fig. 56). Here again, the reasons for preferential melting could profitably be discussed.

The Charlestown moraine is thought to have formed because of a belt of shear planes along the ice front. This resulted in a band of dirty ice in the marginal zone, which in turn produced a belt of thick ablation moraine. As the underlying ice melted, the ablation moraine shifted both by sliding and water transport into low places on the ice surface. The present topography of the moraine is essentially an inversion of the ice surface during the last stages of wastage--that is, high places on the ice core are represented by topographic lows, and ridges and mounds mark places where core ice was thin or absent.

The cleaner ice north of the moraine melted more rapidly than the debris-covered ice. As a result, for a long while the Charlestown moraine had a thick ice core that was isolated from the ice sheet to the north. Drainage from the deglaciated tract north of the moraine was partly submoraine, that is, meltwater flowed beneath the surface of the moraine through ice tunnels and enlarged crevasses in the ice core. In the Kingston moraine this submoraine drainage seems to have been largely localized at two places. These are both marked by deep pond-filled kettles and a sag in the crest-line of the moraine. In short, there is a deficiency of material making up the moraine along these drainageways. This is probably the result of the flushing action of the subsurface drainage, washing away rock debris in the crevasses and englacial debris from the walls of the drainage channels.

These sags can be seen from Stop 2. One is north of Stop 2 and the other is to the WNW. It is interesting to note that the outwash fans head up to these drainageway sags and that a series of ponds and channelways also head up to what must have been the springs at the outlets of the submoraine drainage.

About a mile northeast of Stop 2, the ridges and mounds of the Charlestown moraine decrease rather abruptly in height and the moraine blends into a low hummocky topography that is marked here and there by low ridges, angular to sinuous in plane, like the ice-fracture fillings of the Charlestown moraine but on a reduced scale. This low hummocky area makes up the southeastern part of the Kingston quadrangle and extends from the shore north to Wakefield. Two large salt ponds, Point Judith Pond and Potter Pond, are situated in this belt.

The low hummocky area is underlain mainly by gravel and sand but interbedded with these are rather extensive lenses of till. The till is dark gray in color, unlike the nearly white till of the Charlestown moraine, and is rich in the graphitic metasedimentary rocks of Pennsylvanian age of the Narragansett basin. There is a zone of mixing along the east end of the Charlestown moraine and the western edge of the low hummocky area where debris both from dark Narragansett basin rocks and light crystalline rocks occur together in the drift.

This low hummocky terrain is thought to represent a thick and relatively extensive ablation moraine. This is in contrast to the Charlestown moraine where the ablation moraine was confined to a narrow marginal zone of dirty ice. It is referred to on the Kingston quadrangle map as the "Ablation-moraine complex of the Narragansett basin ice." It grades both upward and northward into deposits that can be called ice-contact deposits. The boundary between the two types of deposits is arbitrary.

The ablation moraine complex of the Narragansett basin ice is probably the same age as the Charlestown moraine and may represent a lobate projection of the ice sheet in this section beyond the line of the Charlestown moraine. The narrow belt of moraine-laden shear planes of the Charlestown moraine gave way to a broader development of shearing and dirty ice in the Narragansett basin lobe. On melting, the difference in englacial moraine per unit area of ice (greater in the Charlestown moraine) produced a difference in the ultimate thickness of ablation moraine, and thus in the resulting morainic topography.

EN ROUTE TO STOP 3.

We descend from the low till-covered hill and travel west and then north (Moonstone Beach Road) across the outwash plain that originates at the foot of the Charlestown moraine. The road mounts a small area of ground moraine at the southern edge of the Charlestown moraine. We turn west on Rte. 1 and travel about $\frac{1}{2}$ mile along the base of the moraine.

STOP 3. Post Road (U.S. 1), just west of Grandly Hill Road (477,360 ft., 114,350 ft.), (40 minutes).

This private road cuts through a colluvial rampart. This is a marginal ridge paralleling the trend of the moraine that is thought to have formed by ablation moraine (till) sliding down the steep edge of the ice and piling up as a talus along the ice toe. Ridges, such as this one, are found at several places, both along the south edge and north edge of the moraine. Those along the north edge formed when the ice core of the Charlestown moraine had become detached from the glacial ice to the north.

The colluvial rampart is made up of light till typical of the moraine and of the ground moraine to the north and south. It is fairly sandy for a till and is made up largely of quartz and feldspar and pebbles from the granites and alaskites that crop out widely to the north. Before this cut was bladed one could see the crude stratification of the till dipping south parallel to the front face of the ridge. The till was bouldery. Now most of the boulders have been removed, some of them in the pit to the north.

About 100 yds. to the north is a badly slumped pit in a small rimmed morainic mound ("ice-block cast"). Characteristic of the upper part of many of these mounds is the horizontally bedded fine sand that we find here. It overlies typical light till. In addition the layer of massive eolian silt which forms the surface cover of much of southern Rhode Island can be seen in this pit.

The mounds are thought to represent, first of all, the filling of a hole in the morainic ice core. The hole seems to have resulted from the rapid melting of a block of ice separated from the adjacent ice by fractures. When the hole reached a certain depth, large volumes of ablational till slid into it from the surrounding area. This sediment fill impeded downward drainage through the ice and a pond then formed in which lacustrine sand was deposited. Later, when the ice supporting the sides of the hole had melted away, the sediment filling the hole formed a mound, such as we see here. The process of making a depression, filling it, and then removing the walls of the depression is essentially that of casting--hence the term "ice-block cast," for these ice-hole fillings.

EN ROUTE TO STOP 4.

We will travel east on Rte. 1 along the toe of the moraine.

STOP 4. East side of Wash Pond (486,400 ft., 114,950 ft.), (40 minutes).

Wash Pond, a rimmed kettle, or ice-block mold.

Seen on aerial photographs Wash Pond is rimmed by a high ridge which in plan is made up of straight, or slightly curved sections, meeting at sharp acute angles (Kaye, 1960, Fig. 54). The ridge seems clearly to follow a set of fractures or crevasses. It may therefore be assumed that Wash Pond spatially represents an ice block and the fractures that outlined it are today marked by the ridge. Unlike the ice-block cast of Stop 3, this ice block did not form a depression but rather a high on the surface of the ice core of the Charlestown moraine. Using the cast and mound terminology, Wash Pond can be referred to as an "ice-block mold." The reasons why some fracture outlined ice blocks that melted more rapidly than the general ice surface and others defined ice blocks that melted less rapidly could be profitably discussed at this stop. However, keep in mind that the deep rimmed kettles of this eastern part of the moraine are probably partly the result of the flushing action of submoraine drainage.

Two small road cuts on the wooded road behind the house show: (1) The presence of some dark graphitic pebbles from the Narragansett basin in the otherwise typical light till. These become more numerous as we go east. (2) The presence of sand as well as till in the ridges. The relationship of sorted to unsorted drift in the ice-fracture fillings is unpredictable, discontinuous and chaotic, and can be accounted for by the dynamic surface of the moraine during its depositional history. This resulted in undrained depressions, ephemeral ponds in which water sorting took place for a short time.

Notice how difficult it is to determine the essential configuration of the ridges from the ground. Aerial photographs are essential in studying this terrain.

EN ROUTE TO STOP 5.

A new highway is under construction and a brief stop will be made to examine a new exposure of the contents of the moraine if one can be found. The new road and the old, and we hope also the route we will be allowed to travel, follow around the eastern margin of the moraine. To the left (northwest), the ridges of the moraine drop off to form the topography of low relief on the right side of the road.

A low ice-fracture filling more than half a mile in length follows the west side of U.S. 1 at the east end of the moraine. The private road onto which we turn cuts across this ridge and the buses will park in the eastern end of the moraine, near excellently formed ridges and mounds.

STOP 5. Northeast side of Hot House Pond (488,700 ft., 119,550 ft.), (40 minutes).

Rimmed ice-block casts, ice-fracture filling, and paired ice-fracture fillings.

We will walk up the steep face of an ice-fracture filling that is about 60 feet high. An excellent view of the ablation moraine of the Narragansett basin ice and Point Judith Pond can be had from the top of this ridge. This ridge is paralleled by another and higher one about 100 yards to the north. The land between the ridges is not as low as on either side so that, in effect, these ridges are ramparts on a long narrow ice-block cast. Paired parallel ridges of this type occur at several other places in the eastern part of the moraine.

As we walk along the road to the small rimmed ice-block cast at the end, we will pass an exceptionally fine configuration of ridges with angular intersections. Again, however, this is difficult to appreciate on the ground and one needs aerial photographs to see their relationships.

At the end of the road is a small ice-block cast. The houses are built on the rim (the rim was partly removed to make room for the newer house). Radiating out from this mound are two fine ridges which intersect others. White Pond (to the north) and Hot House Pond can be explained in the same manner as Wash Pond (Stop 4).

EN ROUTE TO STOP 6.

The buses will travel northeast along the edge of the ablation moraine complex of the Narragansett basin ice to Wakefield, and then south along Point Judith Road. This road follows the crest of a ridge that is shown on the surficial map of the Narragansett Pier quadrangle as the Point Judith moraine, believed to have been deposited at the west side of the Narragansett Bay-Buzzards Bay ice lobe. The topography of the moraine ranges from smoothly rolling to moderately knobby, and is more irregular to the south; but nowhere does it show the very sharp topography and distinctive form elements of the Charlestown moraine. The material is dominantly till, generally contains thin layers and lenses of sand, gravel, and silt, and was evidently deposited as ablation moraine. Known depths to bedrock range from 10 feet near the west end of Clarke Road to 95 feet at Fort Greene.

We turn west along Escape Route, across the south part of deposits that have much sharper collapse topography than the moraine. These deposits along Point Judith Pond are composed dominantly of sand and gravel, but include much till and till-like material.

STOP 6. Galilee (497,000 ft., 107,800 ft.), (65 minutes).

Lunch at fishing port of Galilee (also called Point Judith, or Point Jude). Bus 1 at George's Restaurant. Bus 2 at Port Side Restaurant. Individual checks. Rest rooms at restaurants.

Galilee is at mouth of Point Judith Pond.

EN ROUTE TO STOP 7.

We go east on Galilee Road, and then south almost to Point Judith.

STOP 7. Sea cliff at east end of Sand Hill Cove (Breakwater Village)
(502,700 ft., 102,400 ft.), (40 minutes).

This cliff exposes ablation moraine deposits of the Point Judith end moraine. The material consists of till and till-like material interbedded with sand and silt. The stratification is more or less deformed throughout, presumably as a result of collapse. However, much of the strong contortion that is shown in the upper few feet appears to die out downward, and may well be a result of late-glacial frost action. The drift is overlain by late-glacial eolian silty sand that contains ventifacts.

A cobble of cumberlandite found on the beach in front of this cliff represents the west edge of the indicator fan of this distinctive rock type, derived from an outcrop 44 miles north. The thinness of the beach deposit is indicated by the extensive areas of bare till platform on the foreshore. A thin lens of wood-bearing peat is exposed beneath the beach gravel at about high-tide level, at the west end of the main cliff. This probably dates from the sea-level rise of the last few thousand years.

The short, low cliff in till just to the west exposes some interesting pedologic features; similar thick dark sandy soils have been seen at low altitudes at several coastal localities in southeastern New England.

EN ROUTE TO STOP 8.

We go north on Ocean Road, first along the thick ablation moraine deposits. Black Point is the south end of the granite shoreline, and here we pass onto thin till overlying bedrock. At Narragansett Pier we turn west and pass onto collapsed glaciofluvial deposits, then around the head of Point Judith Pond again into the ablation moraine complex, to a pit near the new bypass road.

STOP 8. Borrow pit a quarter of a mile north of Congdon Cove (497,600 ft., 124,200 ft.), (35 minutes).

Ablation moraine complex of Narragansett basin ice.

This large borrow pit cuts across one of several ice-fracture fillings. The deposits exposed consist of: eolian silt on top, then lenticular gravel and sand with one or more layers of dark gray till. The sand and gravel is outwash and the till layers represent mudflows originating from blocks of higher-standing ice that had been mantled with unsorted ablation moraine. This ablation till flowed over the outwash plain probably during summer thaw.

Notice the anticlinal structure of the ice fracture filling. This is the result of the process of topographic inversion that followed the final melting of the sheet of buried ice. By "inversion" is meant that low places on the buried ice become the loci of topographic highs. To explain this process further we must assume that the subglacial floor was fairly smooth and that the superglacial deposits had a fairly flat surface--as, for example, an outwash plain. It can be seen, then, that the ultimate topography depends entirely on the thickness of sediment at any given point. Sediment will be thickest in an enlarged fracture or crevasse. These are slowly raised in relief as the surrounding buried ice melts. The anticlinal structure results from the gradual dropping down of the sediments on either side. Thus, we have a passively formed anticline. The crest of the anticline may therefore have suffered no collapse at all and may, in fact, give us the elevation of the outwash plain at the time of deposition. If it does, we can measure directly the thickness of the buried ice in the neighborhood by the difference in altitude of a point on the surface and the altitude of the top of the ice-fracture filling.

In this locality the average thickness of ice at the time the uppermost layers of sediment were deposited could not have been much in excess of 30 feet. It is quite clear that when dealing with deposits originating at this late stage of ice-wastage, the border line between ice-contact deposits and ablation moraine is not easy to define (Kaye, 1960, p. 371-372).

EN ROUTE TO STOP 9.

We travel across the ablation moraine complex, turning left on Tuckertown Road. About 0.3 mile west of this turn, the road mounts the head of a long narrow belt of outwash extending about 2 miles east-west, that grades down to the west. This outwash was largely derived from the Narragansett basin ice which, at that time, must have been at least 80 ft. thick at its west margin (at the outwash head) and which must have occupied all or most of the southeastern corner of the Kingston quadrangle (Kaye, 1960, Fig. 60). This outwash therefore is probably somewhat older than the uppermost deposits seen on Stop 8.

This outwash further indicates that the lowland north of the Charlestown moraine was free of ice when an appreciable thickness of ice existed to the east, in the Narragansett basin.

We take a right turn at Tuckertown Four Corners and retrace our steps of early this morning. We ascend the outwash plain in the Chipuxet Valley to a gravel pit, now unfortunately used as a dump.

STOP 9. Gravel pit about 3/4 mile north of University of Rhode Island (491,000 ft., 150,600 ft.), (35 minutes).

The outwash is undisturbed and horizontal in the west part of the pit; it is somewhat collapsed toward the contoured kettle; and at the east side of the pit the till of the adjacent hill is exposed beneath a thin wedge of gravel. In much of the pit, the top of the outwash is a poorly sorted mudflow layer. The gravel is covered by eolian sandy silt that contains ventifacts.

For more than six years, this pit has usually provided the best exposures of late-glacial frost features in Rhode Island. The uncollapsed part of the outwash shows abundant involutions in the lower part of the eolian material and extending down into the top of the gravel. These involutions are approximately symmetrical in vertical section and equidimensional in horizontal section, and may easily be distinguished from load casts or from wind-throw structures. This part of the pit has produced about eight ice-wedge structures over the years, but the only one now visible is not nearly as good as the one we shall see at Stop 11. The wedges vary from 1 to 2 feet wide at the top, and end at depths of 6 to 9 feet. They are known from very few localities, and as far as we can tell from their orientation, they occur only as separate structures, not as nets. The perennially frozen ground that they indicate might have been only thin and patchy.

On the east side of the kettle, involutions are overturned on the slope. The kettle is partly filled with poorly sorted sand, probably a solifluction deposit. The east side of the pit exposes solifluction tongues that came down the adjacent hillside and extended short distances onto the outwash terrace. The tongues are composed mostly of eolian material, but carry many boulders.

EN ROUTE TO STOP 10.

We travel about 2000 feet north on the outwash plain, into the Slocum quadrangle.

STOP 10. End moraine east of Hundred Acre Pond (491,500 ft., 152,300 ft.), (40 minutes).

A small moraine is mapped here by W. R. Power, Jr., at the head of the outwash plain that includes Stop 9. The moraine is a narrow belt of bouldery knobs, and stands about 20 feet above the head of the outwash.

This moraine appears to be part of a thin line of morainic features rising out of the outwash in the north central and northwestern parts of the Kingston quadrangle. On the Kingston quadrangle geologic map a long narrow ridge situated about 2 miles west-southwest from Stop 10 is labelled crevasse-filling. A mile or so further west, a belt of kamy hills cuts across the Usquepaug valley. Plate 33 of the Kingston quadrangle report suggests an ice front responsible for this thin morainic belt. If these features are correctly interpreted, then the ice readvance or retreatal stillstand at this line was certainly a minor affair.

First we shall walk across the head of the outwash to the railroad cut, which shows the knobs and boulders; the cut is now badly overgrown, but till may be dug out of it; a glimpse is obtained of the lower and younger outwash to the north.

Next we walk along the road through the moraine to a small pit on the north side of its crest. The pit exposes collapsed sand and gravel, with many boulders and a few lenses of till-like material. Finally we walk down the ice-contact face of the moraine, along a post-glacial gully that contains a lag concentration of large boulders.

EN ROUTE TO END OF SATURDAY TRIP.

We travel back down the outwash plain to the Keaney Gymnasium parking lot, where we plan to arrive before 5:00 p.m.

SUNDAY, MAY 20.

9:00 a.m. - Buses leave Keaney Gymnasium parking lot.

EN ROUTE TO STOP 11.

We travel east to Kingston, southeast on Kingston Road (where we pass from the till upland to glaciofluvial deposits), and east on Saugatucket Road.

STOP 11. Pit on west side of North Road, north side of Saugatucket Pond (501,000 ft., 138,200 ft.) (15 minutes).

The brief stop here is to show a good ice-wedge structure, first seen in 1954 and still visible. This one, like most others in the area, lacks any evidence of lateral compression of the bedding of the adjacent outwash. The structure is best shown by the eolian sandy silt that extends downward into the outwash, but the outwash is also collapsed along the sides of the wedge.

EN ROUTE TO STOP 12.

We travel north to Rose Hill; then east on Mooresfield Road, across the Saugatucket valley deposits; north on Tower Hill Road along the hilltop; and then west on Shermantown Road onto gravel again.

STOP 12. Old Post Road (507,500 ft., 161,400 ft.) (20 minutes).

The rest of this morning's excursion is concerned mainly with discussing the validity and usefulness of the chronologic classification of the glaciofluvial deposits, i.e., the sequence concept. Basically, this concept consists of attempting to reconstruct the glaciofluvial constructional forms without the complications caused by melting of buried or partly buried dead-ice masses.

This stop is on an esker that is part of the kettled ice-contact head of sequence 2a, which drained southwest over the upland to Saugatucket River. This head stands nearly 100 feet above the deposits of sequence 4, which drained southeast along Mattatuxet River.

EN ROUTE TO STOP 13.

We travel north and northwest, and then west on West Allenton Road, across deposits of sequence 4 and 3 and "morainic kames." The morainic kames, which are unpredictable mixtures of till and water-laid materials, are the first ice-hole deposits laid down as the ice melted away from the moraine to the west. We travel across the moraine, and then onto the outwash plain west of it.

STOP 13. Indian Corner Road, east of Slocum (499,000 ft., 163,900 ft.) (15 minutes).

This stop is in the midst of the potato fields that occupy most of this extensive outwash plain. The plain is correlated with the moraine that lies along the boundary between the Slocum and Wickford quadrangles. A high part of the moraine (about 80 feet above the outwash plain) lies directly east of this stop.

EN ROUTE TO STOP 14.

We travel north on Swamptown Road along the west side of the moraine, whose middle part stands very little above the outwash plain. To this part of the moraine is related the Belleville esker, which evidently marks a major feeder to the outwash plain. The road descends the moraine face to deposits of sequence 3, the first integrated deposits formed after the moraine. We travel on Swamptown Road, Colonel Rodman Highway, and Old Baptist Road, on more morainic kames and an intervening strip of sequence 4, and then on sequence 6 to beyond Davisville.

STOP 14. Pit on northwest side of School Street (508,600 ft., 195,000 ft.)
(25 minutes).

This small pit, now badly slumped, is one of the very few that have shown deposits of more than one chronological unit. The kame is composed of medium and fine sand, extremely light in color, and probably glaciolacustrine; the sand is capped by a few feet of gravel, the stones in which are almost entirely of crystalline rocks. After the sand collapsed to the northeast, an erosional shelf was cut in it, and filled with coarse gravel. This gravel, like most of that in the vicinity, contains a large proportion of stones of Pennsylvanian metasedimentary rocks, and belongs to sequence 6. The kame is one of a row of four, the deposits of which are similar in texture and lithology to the one described; these kames, though they hardly fit the original definition of a sequence, are mapped as sequence 5.

After the gravel of sequence 6 was deposited, some of the kame material moved down the slope onto the gravel as a poorly sorted solifluction deposit. This was in turn covered by the late-glacial eolian material.

EN ROUTE TO STOP 15.

We travel on sequences 6 and 6a, northeast on School Street and then south on U.S. 1, passing another of the sequence 5 kames on the south side of Sandhill Brook.

STOP 15. Pit on north side of Newcomb Road, shortly east of U.S. 1
(513,300 ft., 192,000 ft.) (25 minutes).

This pit exposes glaciofluvial (not deltaic) gravel and sand overlying glaciolacustrine (bottom deposit) sand and silt. This is a very common relationship in this and some nearby areas; in fact, no delta structure has been exposed in the quadrangle, except in the kames of sequence 5. The surface gravel of most of sequence 6a is evidently underlain by such lake deposits. At this pit, the sand contains many ice-rafted boulders, and overlies till-mantled bedrock. The eolian sandy silt in some parts of the pit contains unusually large numbers of ventifacts.

EN ROUTE TO KINGSTON.

We travel south on U.S. 1 to Wickford, mostly near the contact between sequence 6a and the till hill to the west. On U.S. 1A, we travel on deposits which look like terraces, little collapsed, but which contain a great deal of till. These deposits are probably the mudflow-covered head of sequence 6b.

We cross the Belleville esker, and travel on sequence 4 south and then east toward Hamilton. About half a mile south of Hamilton, U.S. 1 rises across a nicely collapsed head of sequence 4, standing 20-30 feet above sequence 6b. We continue southward on U.S. 1 on the hilltop, and turn west on Rte. 138, crossing the collapsed terraces of the Pettaquamscutt River valley, and reaching the parking lot at about 12:30 p.m.

ITINERARY OF OPTIONAL TRIP

SUNDAY AFTERNOON, MAY 20.

EN ROUTE TO STOP 16.

We leave Kingston by private car, and travel west on Route 138 and then southwest and south on Route 2, to Charlestown. For most of this distance we cross alternating till-mantled bedrock hills and glaciofluvial deposits, including several broad outwash plains. Just north of Charlestown we cross the Charlestown moraine, though its topography is not as conspicuous along this road as where we saw it Saturday. We turn west on U.S. 1, across kettled outwash in front of the moraine. If the day is clear, Block Island (complex drift overlying Cretaceous) may be seen directly to the left (south-southeast) across Ninigret Pond. From that pond west to Weekapaug, there is little outwash in front of the moraine, and we travel very near the contact between the end moraine and till-mantled bedrock. West of Weekapaug, outwash again lies in front of the moraine. At Langworthy Corner we turn north to Dunn Corner, or, if time permits, we will continue along the moraine front to Winnapaug Road, cross the moraine to the north (using a new road on the west side of Westerly Airport), and travel east to Dunn Corner, where we will have lunch.

Dunn Corner is almost in the center of a large triangular delta, about half a mile across, banked against the north side of the moraine. Excellent exposures near the ice-contact slope of this delta are provided by two large pits.

STOP 16. Pit on east side of Woody Hill Road, in northeast corner of delta.

At present this provides an unusually large and clean exposure of delta foresets, with overlying and interbedded bouldery mudflow and other materials derived from ablation moraine on the adjacent ice. It is noteworthy that the crude local materials extend only a very short distance from the ice-contact slope.

STOP 17. Pit on west side of Old Shore Road, in northwest part of delta.

Similar materials are equally handsomely exposed in this pit. Collapse structures, and thick kettle fillings of eolian material are shown. Both of these pits are highly photogenic in proper light.

EN ROUTE TO STOP 18.

We travel north along Old Shore Road on low glaciofluvial deposits. On the east side of the road is a higher (and older) kame; a pit has removed the crest of the kame, exposing collapsed ice-contact deposits. We continue north along a kame terrace, and turn west to an excavation near the railroad.

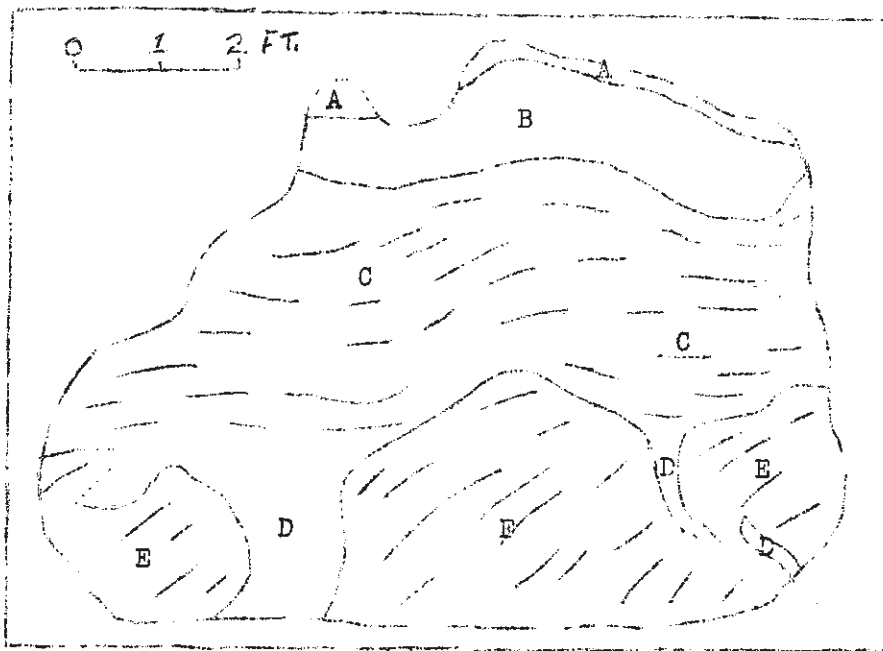
STOP 18. Trench on hillside, about 3500 feet north-northwest of McGowan Corners (intersection of Old Shore Road and Westerly-Bradford Road).

Weathered rock is exposed at many places in southeastern New England, commonly beneath unweathered drift. Most of it is the so-called rottenstone, generally a coarse-grained granite or gneiss that is disintegrated but very little decomposed. At a very few localities, including this one, very strongly decomposed rock is exposed, more or less kaolinized. An eight-foot thickness of decomposed rock was exposed here before the ravages of winter. It has undergone strong creep (preglacial? interglacial? periglacial?), and contains a few sand lenses perhaps derived from ice lenses. This weathered bedrock is overlain by a solifluction layer composed partly of weathered rock and partly of late-glacial eolian material containing ventifacts. This upper layer overlies and is interbedded with the adjacent kame terrace deposits.

STOP 19. Cut behind the Duk-In restaurant, south side of Rte. 84 at intersection of Voluntown Road, in west-central part of Ashaway quadrangle, North Stonington, Conn.

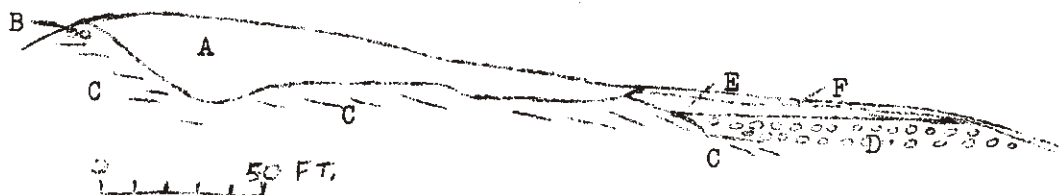
If time permits and the cut is in good enough condition, we can visit this other exposure of deeply decomposed bedrock. This was formerly exposed to a depth of 14 feet, and is overlain by a thick solifluction layer. A few wedge structures in the weathered rock, filled with solifluction rubble, were formerly exposed.

I. SECTION AT STOP 19 (Note: the itinerary states that this is on Route 84; but this is now renumbered Route 95)



- A. Spoil.
- B. Eolian sandy silt; contains fragments of weathered rock and a few transported pebbles.
- C. Decomposed schist and alaskite, moved by solifluction; contains a few transported pebbles.
- D. Decomposed rock rubble filling wedge-shaped fissures in weathered bedrock; coarser rubble in the wider fissure.
- E. Decomposed bedrock, dipping to the left.

II. Section at STOP 14



- A. Part of pit cut back and covered by slump and vegetation.
- B. Thin pebble gravel on cap of kame; contains less than 1% of Pennsylvanian rocks.
- C. Sand of kame; consistent dip northeast may be partly deltaic and partly collapsed. Sequence 5.
- D. Pebble-cobble gravel of adjacent terrace; contains about 50% of Pennsylvanian rocks. Sequence 6.
- E. Solifluction and/or slopewash deposit; derived from kame, as pebbles include very few Pennsylvanian rocks; intergrades and intertongues with terrace gravel in a few places.
- F. ~~XII~~ Late-glacial (early postglacial) eolian sandy silt.

Friends of the Pleistocene - Kingston, R. I., 1962
List of Participants

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Harvard

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U. S. G. S.

J. A. Baker
U. S. G. S.

A. L. Bloom
Cornell

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D. W. Caldwell
Wellesley

R. L. Cameron
A. F. Camb. Res. Lab.

K. M. Clayton
Harpur

N. K. Coch
Yale

G. G. Connally
N. Y. State

J. Cotton
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J. A. Elson
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Mrs. J. A. Elson

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J. G. Fyles
G. S. Canada

N. R. Gadd
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L. Goldthwait
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Dublin, Ireland

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W. S. Newman
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Mrs. A. L. Washburn

J. H. Waters
Hanson, Mass.

N. P. Webber
Wellesley

J. M. Weigle
U. S. G. S.

Friends of the Pleistocene

1. 1934 Durham and Hanover, New Hampshire; participants were J. W. Goldthwait, G. W. White, R. F. Flint; also, for part of time, D. H. Chapman, E. H. Perkins, L. W. Fisher.
2. 1935 New Haven-Hartford, Connecticut; R. F. Flint.
3. 1936 Rhode Island shore, Cape Cod; Kirk Bryan.
4. 1937 Hanover-Mt. Washington, New Hampshire; J. W. Goldthwait, R. P. Goldthwait, R. J. Lougee.
5. 1938 Black Rock Forest, Cornwall, New York; C. S. Denny and H. M. Raup.
6. 1939 Northern New Jersey; Paul MacClintock.
7. 1940 Western Cape Cod; K. F. Mather, R. P. Goldthwait, L. Thiesmeyer.
8. 1941 Catskill Mountains; J. L. Rich.
9. 1946 Lowell-Westford, Massachusetts; L. W. Currier and Kirk Bryan.
10. 1947 Eastern Finger Lakes, New York; E. T. Apfel.
11. 1948 Toronto-Barrie, Ontario; A. K. Watt and others.
12. 1949 New Brunswick-Trenton, New Jersey; Paul MacClintock and others.
13. 1950 Ithaca, New York; O. D. von Engeln.
14. 1951 Brandywine-Sunderland, Maryland; J. T. Hack.
15. 1952 Columbus-Xenia, Ohio; R. P. Goldthwait.
16. 1953 Ayer, Massachusetts; L. W. Currier and J. H. Hartshorn.
17. 1954 Wellsboro-Towanda-Elmira, Pennsylvania-New York; C. S. Denny and W. H. Igford.
18. 1955 Malone-Canton, New York; Paul MacClintock.
19. 1956 Drummondville, Quebec; N. R. Cadd.
20. 1957 Potsdam, New York; J. N. Harris.
21. 1958 Harrisonburg, Virginia; J. T. Hack and J. C. Goodlett.
22. 1959 London, Ontario; Aleksis Dreimanis.
23. 1960 Dunkirk-Olean, New York; E. H. Muller.
24. 1961 Portland, Maine; A. L. Bloom.
25. 1962 Kingston, Rhode Island; C. A. Kaye and J. P. Schafer.