The Surficial Geology of the Hartford South Quadrangle

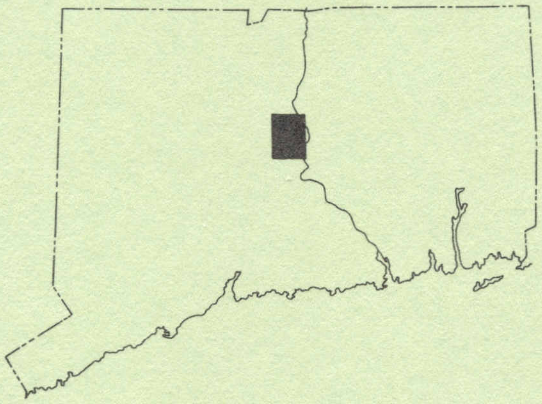
WITH MAP

Open Map

Open Figure 3

Open Figure 4

BY R. E. DEANE



STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

A DIVISION OF THE DEPARTMENT OF AGRICULTURE
AND NATURAL RESOURCES

1967

QUADRANGLE REPORT NO. 20

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Late of the University of Toronto

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PREFACE

Professor R. E. Deane of the University of Toronto, together with several of his students, was tragically drowned on October 23, 1965, while conducting underwater research in Lake Ontario.

The Connecticut Geological and Natural History Survey began its program of bedrock mapping on a quadrangle basis in 1949 but it was not until 1953 that large-scale mapping of surficial deposits was begun. In that year, Deane, then a member of the Department of Geology at the University of Indiana, started detailed surficial mapping in the Middletown quadrangle and finished the field work. He deferred publication, however, until he could complete a block of four quadrangles, Middletown, Hartford South, Middle Haddam, and Glastonbury. By 1956 field work had been virtually completed on all four quadrangles and reports prepared on the Middletown and Hartford South quadrangles.

By this time surficial mapping in adjacent parts of the state had been started by U.S. Geological Survey geologists working under a cooperative agreement with the State Survey. It became apparent that some standardization in nomenclature and usage would be advantageous, since products of one organization might be published by the other. For this purpose it was necessary to hold a conference in the field to examine and resolve certain critical questions. In the meantime, Deane had moved to the University of Toronto, where his heavy program of undergraduate and graduate teaching, as well as his new research programs, prevented holding such a conference until August 1958. At that time Deane and Dr. Joseph Hartshorn of the U.S.G.S. agreed on changes that should be made on the map and in the text. Deane, however, could not find time to make the necessary corrections and alterations until his sabbatical leave in 1962, when he came to Connecticut at his own expense, spending more than three months in the field examining the many new roadcuts, gravel pits, and other exposures. He also collected the enormous amount of subsurface data obtainable from new highway borings, seismic tests, and water wells. He essentially remapped the Hartford South and Middletown quadrangles and also revisited the Middle Haddam and Glastonbury quadrangles. After his return to Toronto, he prepared this report on the Hartford South. It was critically reviewed by Professor R. F. Flint and Dr. Hartshorn and edited by Dr. Lou Page. The manuscript had been returned to Professor Deane shortly before his ill-fated accident. There remained some final questions arising largely from the proposed use of a new revised topographic base. In addition, some adjustments were necessary, chiefly because of information from new roadcuts. I am especially grateful to Dr. Hartshorn, Dr. Lou Page, and Dr. Henry Aldrich for their effort to present this report as Deane would have liked it. I also wish to thank Dr. Joseph Weitz for data on exposures along Interstate Highway 91, which was completed after Deane's last trip to the field.

Deane described evidence of glacial Lake Hitchcock which he found at many places in the quadrangle. He elected to show the shoreline at approximately the 150-ft contour. Other geologists working in New England since Deane began his mapping have debated at length over the difficulty of locating shorelines of any glacial lake. Critical data may be available only at a few places. Nevertheless, such discussions have recently crystallized a strong view by some that the shoreline of Lake Hitchcock is now sloping and that it cannot be represented by a single contour line on the present map. Dr. Deane had no opportunity to review the latest information and to decide whether or not the evidence was compelling enough to require revision of his interpretation.

This statement is presented so that the reader will understand that the work on which this report is based was done over a period of years, that the map is printed on a topographic base different from that on which the field mapping was done, and that the author had no opportunity to make the final changes and corrections which only an author can make.

Joe Webb Peoples

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The Surficial Geology of the Hartford South Quadrangle

by

R. E. Deane

ABSTRACT

The Hartford South quadrangle, almost at the center of the state, lies entirely within the Central Lowlands of Connecticut, in the Connecticut Valley Triassic area. The preglacial topography, accentuated by pronounced ridges of basalt, confined the flow of the Pleistocene (Wisconsin) glacier to the general direction S 12° W. Drift mantles the bedrock to a depth varying from a fraction of an inch to over 250 ft.

Till, deposited directly from the glacier ice, is the most extensive type of drift and forms a nearly continuous blanket over the bedrock. Two tills are recognized: a basal till that is generally sandy to stony and an upper till rich in silt and clay. The upper till is evidence of a minor readvance, the Middletown readvance of the Wisconsin glacier.

Glaciofluvial deposits of sand and gravel are widespread and include several different types of sediments. Ice-contact stratified drift forms the bulk of these deposits, grading into stream sediments which lack ice-contact features.

Glaciolacustrine varved clays deposited in a sequence of temporary glacial lakes, climaxing with Lake Hitchcock, are present within the quadrangle. They attain a thickness of 165 ft beneath the Connecticut River floodplain. The shoreline of Lake Hitchcock is marked by discontinuous deposits of beach sand and gravel at elevations up to about 150 ft. In many areas, lake-bottom sand, silt, and gravel lie below this level and the altitude (about 45 ft) at which Lake Hitchcock became the Connecticut River in this quadrangle. The dam that held Lake Hitchcock at the 150-ft level was chiefly formed by the sand and gravel that filled the Connecticut Valley below Middletown.

Terrace alluvium is limited to the valleys of the Connecticut and Mattabesset Rivers. Postglacial sediments include alluvium, sliderock, swamp deposits, windblown deposits, and artificial fill.

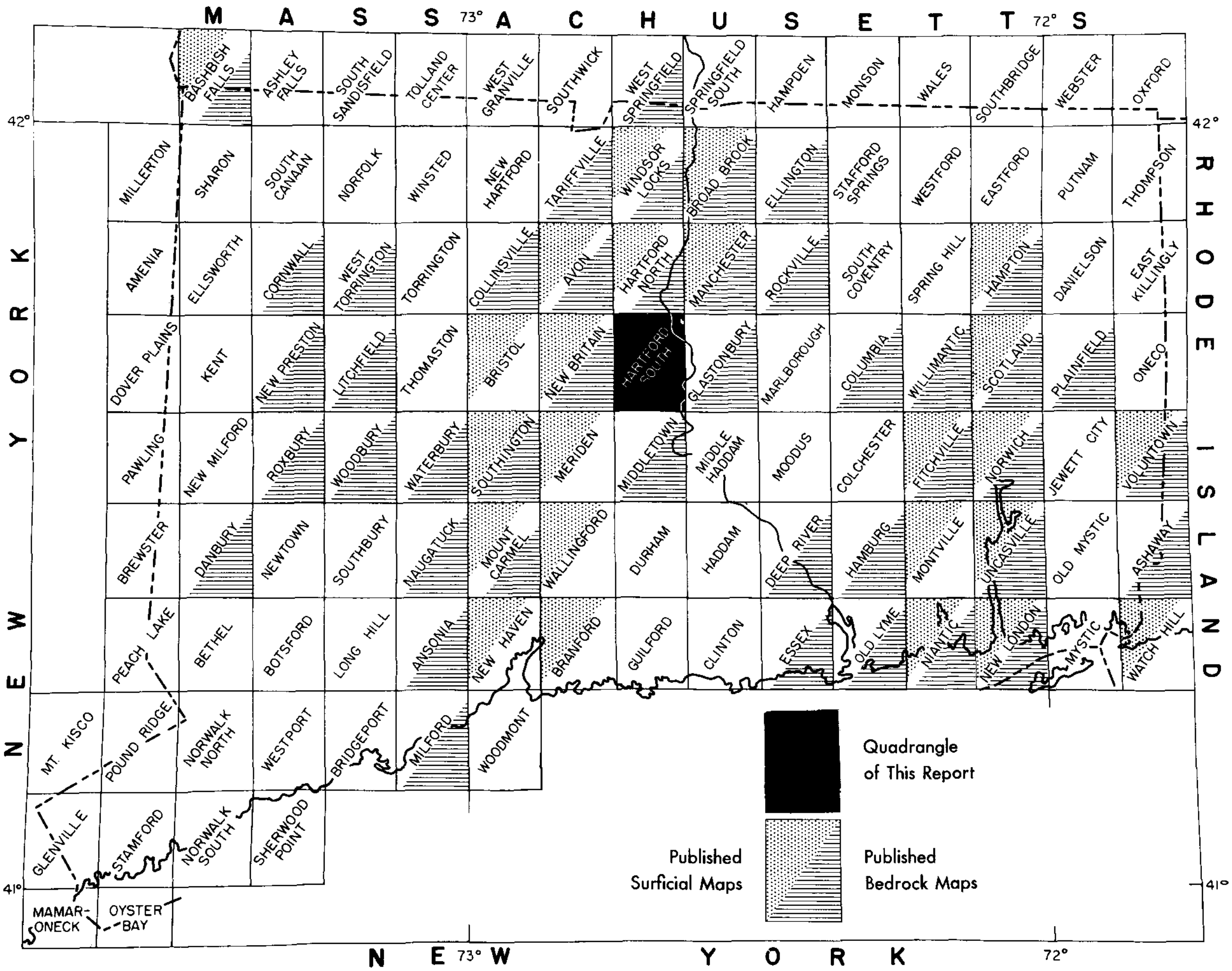

Fig. 1. Index map of Connecticut showing the location of the Hartford South quadrangle, and of other published quadrangle maps.

The potential of the area as a supplier of sand and gravel, ground water, humus, and fill is limited not so much by the reserves as by the accelerated rate of industrial and housing developments which make many of the deposits unavailable.

INTRODUCTION

The Hartford South quadrangle (pl. 1, in pocket), with an area of about 55 sq. mi., lies near the center of the state of Connecticut (fig. 1). It includes parts of the Towns of Berlin, Rocky Hill, Glastonbury, Newington, Wethersfield, West Hartford, and East Hartford in Hartford County, and Cromwell and Portland in Middlesex County. Part of the densely populated Greater Hartford area is situated in the northern part of the quadrangle.

The surficial geology of the quadrangle was mapped by the author in 1954. The map was revised in 1962 to include new features such as excavations and fill. Data were obtained from the U.S. Geological Survey topographic map of the quadrangle, from aerial photographs, and from field studies of land forms and of deposits in such natural exposures as stream banks, in excavations for basements and for sewer and water lines, in pits and roadcuts, and in holes made with shovels and hand augers. Subsurface information was obtained through the courtesy of the Connecticut State Highway Department and the Metropolitan District of Hartford County. Logs from more than 1,700 cores, ranging in length from about 2 ft to 236 ft, were examined.

Helpful field and office discussions of geological problems of the general area with R. V. Cushman, R. F. Flint, J. H. Hartshorn, J. W. Peoples, H. E. Simpson, and many others will be remembered with lasting pleasure.

Numerous investigators have contributed to the knowledge of the glacial geology of the area. Dana (1875, 1876) first established that the region had been glaciated. Rice and Gregory (1906) and Rice and Foye (1927) added further details to the overall picture. Flint (1930, 1933) included the quadrangle in his discussions of the deposits and sequence of events within the Connecticut Valley. Recent publications of particular interest include those dealing with ground water (Cushman, 1960, 1964; Cushman, Tanski, and Thomas, 1964; Randall, 1964), with surficial geology (Cushman, 1963; Hanshaw, 1962; Simpson, 1959), and with soils (Shearin and Hill, 1962). Office files of the Connecticut State Highway Department, the Metropolitan District of Hartford County, and the Ground Water Branch of the U.S. Geological Survey in Hartford contain much valuable information on the subsurface material.

TOPOGRAPHY AND DRAINAGE

The quadrangle lies entirely within the physiographic province known as the Central Lowland of Connecticut, a north-south trending area (fig. 2) between the Eastern and Western Highlands. It is underlain by rocks of Triassic age exposed mainly in such high ridges as Vexation Hill and Cedar Mountain and at Rocky Hill (pl. 1). Glacial and postglacial sediments of varying thickness irregularly mantle the bedrock.

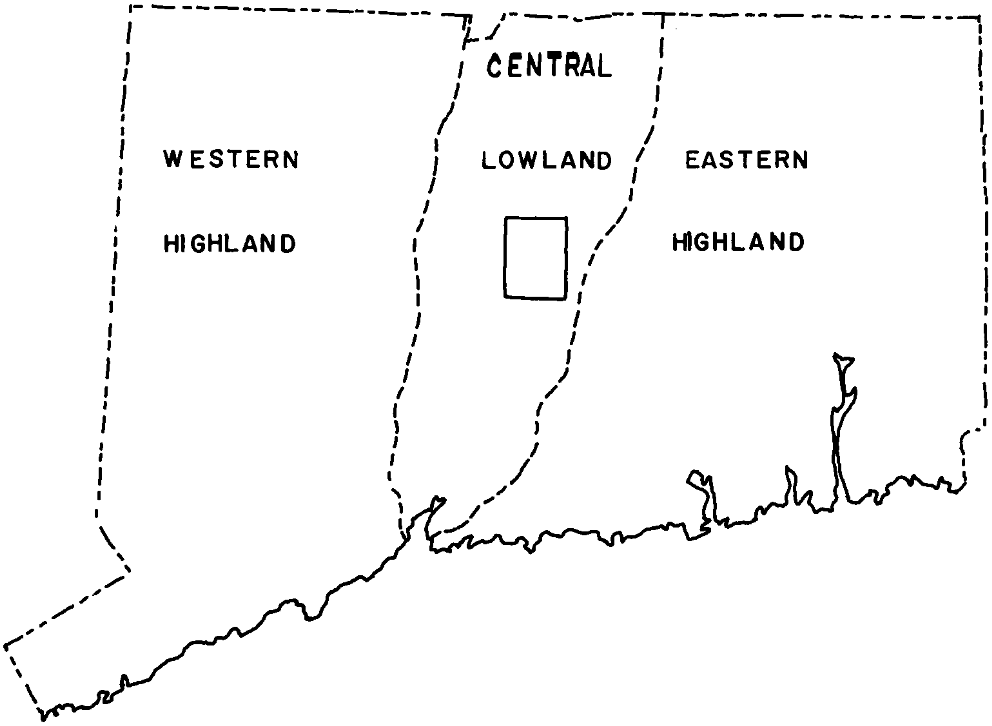

Fig. 2. Map of Connecticut showing boundaries of its three natural regions, and location of the Hartford South quadrangle.

Maximum relief is 390 ft. The lowest point, along the Connecticut River, is only a few feet above sea level; the highest point is on Vexation Hill in the southwestern quarter of the quadrangle. The low, nearly flat floodplain of the Connecticut River contrasts markedly here with the rather rugged topography of Cedar Mountain and Vexation Hill. In most instances the areas of greatest local relief are associated with north-south ridges of eastward-dipping Triassic basalt. Their eastern slopes are therefore gentle, their western slopes abrupt. The ridge extending southwest of Rocky Hill and trending westward and southward to join Lamentation Mountain (in the Middletown quadrangle) is more irregular in form. The Triassic sandstones and shales generally have a more subdued topography.

The glacial and postglacial deposits vary in topographic expression, depending on their mode of origin. On the bedrock ridges the drift is generally too thin to modify the relief of the underlying rock. The drumlinlike hills, most common in the central part of the quadrangle, give the landscape a rolling appearance. The meltwater deposits in the southwestern portion are more irregular topographically. The glacial lake and the floodplain deposits form areas of low relief. Stream erosion is generally moderate; the greatest relief brought about by stream activity is in the lower reaches of the Connecticut River.

The area is drained by the Connecticut River and its tributaries. During low-water stages the gradient in the river is only a fraction of an inch per mile and the flow of water is then affected by the tides in Long Island Sound. During floods the river gradient is high; in the 1927 flood the level dropped, in a distance of 15 mi., from 29 ft at Hartford to 22.5 ft at Middletown.

The two largest tributaries of the Connecticut River are the Mattabesset River, which drains the southwestern corner of the quadrangle and joins the Connecticut River below Cromwell, and the South Branch of Park River, which drains the quadrangle's northwest corner and joins the Connecticut River in Hartford. All other streams are either tributaries of these or flow directly into the Connecticut River.

Most of the streams have eroded deeply enough in places to expose bedrock, for example, in Trout Brook west of Church Street (Newington), in the Mattabesset River east of the Wilbur Cross Highway, in Dividend Brook at the lower end of Dividend Pond, in Goff Brook west of South Wethersfield, and in the floodplain of the Connecticut River at Wethersfield Cove (pl. 1). Most of these streams show bedrock control, for they flow parallel to the regional trend of the ridges through parts of their courses. Two streams that show no bedrock control are Pewterpot and Porter Brooks in the northeastern corner of the quadrangle; these two streams flow on thick lacustrine and fluvial deposits.

There are very few lakes and ponds in the quadrangle, and most are the result of dams or man-made excavations. Small swamps are found in poorly drained depressions of glacial origin or on modern floodplains.

BEDROCK GEOLOGY

Sedimentary rocks (red beds) with interbedded basaltic lava flows (trap) of late Triassic age underlie the drift. The bedrock units, from youngest to oldest, are the Shuttle Meadow Formation, the Holyoke Basalt, the East Berlin Formation, the Hampden Basalt, and the Portland Arkose (Lehmann, 1959). Because these rocks generally dip eastward or southeastward, progressively older rocks crop out toward the west or northwest. This relationship is complicated by numerous faults that tend to repeat the formations and by an anticlinal fold southwest of Rocky Hill.

The Portland Arkose, the principal sedimentary unit, underlies most of the quadrangle east of Ridge Road (Wethersfield) and north of Rocky Hill, south of Dividend Brook, and west of Cedar Mountain. This dominantly arkosic formation ranges in texture from coarse conglomerate to shale.

The East Berlin Formation, chiefly shale and mudstone, is mainly confined to the central part of the quadrangle and extends northward as a thin wedge between Cedar Mountain and Ridge Road (Wethersfield). Smaller areas of this formation underlie the southwestern corner of the quadrangle, and also occur about three quarters of a mile east of the Mattabesset River, in the southern part of the quadrangle.

The Shuttle Meadow Formation occupies a narrow belt on the west side of Cedar Mountain. The formation here varies from shale to sandstone.

The thinner of the two basaltic flows in this quadrangle, the Hampden Basalt, is the more common in outcrop. It forms several low ridges, one in the village of Rocky Hill, another along Ridge Road (Wethersfield), one across Highway 72 east from the Wilbur Cross Highway, another south of the State Veterans Home in Rocky Hill, another north of Robbins Street (Newington), and one along Main Street (West Hartford). The thicker flow, the Holyoke Basalt, forms the higher and more prominent ridges of Cedar Mountain and Vexation Hill. Both flows consist of dense, gray to grayish-green or grayish-blue basalt showing vesicular and amygdaloidal tops.

Individual exposures of bedrock are shown on the map (pl. 1) wherever possible. However, on Cedar Mountain and Vexation Hill only the more prominent exposures are indicated, because here it is impractical to separate drift from bedrock. The cover, in many instances, is only a few inches thick and is composed mainly of coarse, angular fragments of the underlying rock. Such areas, where the drift is 10 ft or less in thickness, are indicated on plate 1. In the densely populated areas, data from water and sewer excavation, supplied by the Metropolitan District, were used extensively to determine depth to bedrock.

PREGLACIAL HISTORY

Just prior to the Triassic Period, nearly 200 million years ago, this part of Connecticut was possibly a rugged, mountainous region of igneous and metamorphic rocks similar to those now underlying the Eastern Highlands. During the Triassic Period, estimated to have lasted about 30 million years, the mountain tops were worn down, faulting took place, and the great block, now known as the Central Lowland of Connecticut, began to subside, more on the east side than on the west. Many rivers, mainly from the highlands to the east, flowed into this basin, depositing muds, sands, and gravels along the mountain front in the form of great alluvial fans which spread out toward the western border of the basin.

At three different times during this long-continued period of subsidence, deposition was interrupted by the outpouring of great quantities of lava that flowed out into the basin. The first or lowest lava flow (Talcott Basalt) is 100 to 250 ft thick, the middle or main flow (Holyoke Basalt) is 300 to 500 ft thick, and the upper flow (Hampden Basalt) is 50 to 150 ft in thickness.

The burial of sediments by the increasing load of additional material changed muds into shales, sands into sandstones, and gravels into conglomerates by compaction and cementation; later, tilting took place. Then north-south faults cut these rocks into long parallel ridges; other faults cut across these, offsetting the ridges so that none of them is continuous over a long distance. A broad fold in the Rocky Hill area left the beds there dipping to the south, east, and north. Over the remaining part of the quadrangle the rocks dip gently eastward.

Deposition, induration, and faulting continued throughout the latter part of the Triassic Period. Subaerial erosion has been more or less continuous ever since, interrupted possibly by submergence below sea level during the Cretaceous Period and certainly by glaciation during the Pleistocene Epoch that began about a million years ago.

SURFICIAL GEOLOGY

General remarks

Surficial geology is the study of unconsolidated deposits that rest on bedrock. In New England most of these surface deposits and some of the topographic features are the result of continental glaciation. Evidence for the former presence of glacial ice in the Hartford South quadrangle lies partly in the nature of the erosion of the bedrock and partly in the nature of the surficial deposits. Because erosion and deposition by wind and water have, of course, continued since the disappearance of the Pleistocene ice, this section would not be complete without a discussion of the postglacial sediments that cover some of the glacial deposits.

Glacial erosion

Although ice is a relatively soft and brittle substance, the erosion of even the hardest bedrock during the movement of a glacier is an established fact. However, this erosion was accomplished not so much by the ice itself as by pieces of rock that it plucked out and incorporated to act as abrasive tools at the base of the moving glacier. This eroded material, ranging in size from boulders many feet in diameter to silt and clay, was incorporated in and transported by the ice and, when the ice melted, deposited as a mantle of drift.

The rate of glacial erosion on the various Triassic beds was greatly influenced by their topography, structure, and composition. Because glacial ice tends to follow valleys, it deepened them. The tough basaltic ridges were less eroded. The bedrock channel of the Connecticut River in the northern part of the quadrangle is more than 200 ft below present sea level. Although some of this depth may be the result of stream action both during preglacial time and during the epoch of glaciation, when sea level was lower relative to the land than at present, some of it is probably due to glacial erosion.

Additional evidence of glacial erosion is found in the polished, striated, and grooved bedrock surfaces. Striations and grooves are useful because, studied in connection with certain topographic features, they indicate the direction of the latest local movement of the ice. Striations and grooves may be preserved on both sedimentary and igneous rocks. However, the ten occurrences recorded in the Hartford South quadrangle are all on outcrops of igneous rocks, even though sedimentary rocks underlie the greater portion of the area. Part of the explanation is that much of the sedimentary rock lies in the preglacial valleys and is covered with thick drift, whereas the basalts form the ridges which are covered with little or no drift. Also, the preservation of striae largely depends on a rock's resistance to weathering. Such properties as hardness, composition, friability, cementation, and polish influence the rate of weathering and, in general, basalts possess characteristics which make them more resistant to weathering than sedimentary rocks.

The striations and grooves discovered in the quadrangle are fairly uniform in direction, ranging only from S 5° W to S 20° W, with an average of S 12° W. Sets of multiple striations, indicating varying directions of ice movement, were not found. The direction of glacier flow was essentially parallel to the general trend of the Connecticut Valley and to the ridges and depressions within that valley. Local topographic variations from the general trend do not appear to have had much influence on the flow of the basal ice, nor did the barrier represented by the Rocky Hill anticline. In other parts of Connecticut the influence of local topography caused more variation in the direction of ice movement (Flint, 1962, p. 6; Hanshaw, 1962).

A number of elliptical hills exhibit long axes more or less parallel with the linear pattern of the topography within the quadrangle. Such streamlined hills are herein called drumlins and are considered to have been formed at the base of moving glaciers, mainly from a plastering on of successive layers of drift (see section on glacial deposits). Consequently, drumlins may be more depositional than erosional in origin, but they are included here because they are, in part at least, formed of eroded material and are essentially molded into shape by glacial action. Many of the drumlins probably have a core of bedrock and would be called rock drumlins but because it is unknown whether or not the hills have a core of rock they are all considered together as drumlins.

Altogether, twenty-four drumlins were mapped in the quadrangle and are indicated on plate 1 by a line marking the long axis of each. A group of seven is located in the center of the quadrangle. Another group of five in the south-central part contains the largest and most impressive examples. The remaining drumlins are scattered throughout the quadrangle. A few, notably in the southeastern part of the area, are partly buried by fluvial sand and gravel, both Pleistocene and Recent. Most of the drumlins are parallel or nearly parallel to the strike of the bedrock, thus confirming the influence of pre-existing topography. The long axes of all the drumlins range from S 5° E to S 35° W, with an average direction of S 12° W, confirming the direction of ice movement indicated by striations.

Glacial deposits

GENERAL REMARKS

Glacial drift includes both ice-laid sediments and water-laid sediments. The former are known as till, an unsorted and unstratified accumulation of rock fragments of all sizes. Water-laid glacial sediments are stratified and sorted as to size of particles, ranging from clay to gravel. They may be further subdivided into (a) glaciofluvial deposits, laid down in meltwater streams, and (b) glaciolacustrine deposits, laid down in lakes of ponded meltwater. This latter group includes the well known varved deposits or rhythmic clay-silt sequences. There are, in addition, transitional deposits more difficult to classify. All these types are well represented within the quadrangle.

TILL

The geologic map (pl. 1) shows that till is the surface material over almost half of the area; elsewhere the till itself is covered with fluvial or lacustrine deposits. The map (pl. 1) does not indicate that till underlies most of the water-laid deposits; this is learned from records of wells and test borings that penetrated to bedrock (figs. 3, 4, in pocket). Approximately 135 test borings along Interstate Highways I-91 and I-491 encountered till beneath stratified drift[1]. In general, till is absent or very thin on bedrock ridges, whether they are exposed ridges such as Cedar Mountain and Vexation Hill or buried ones like those along Highway I-91 near South Wethersfield (fig. 4).

The thickness of the till mantle is variable; it averages about 15 ft and the maximum recorded is 40 ft, measured to the bedrock floor of the valley of the Connecticut River near the eastern edge of the cross-section, along State Highway 3 (fig. 3). Till reaches 37 ft in thickness at the intersection of Gilbert Avenue and Highway I-91, and 36 ft on Wolf Pit Hill. The till in drumlins may be several times as thick, but this cannot be verified.

Till is a heterogeneous mixture of rock particles of all sizes. In the Hartford South quadrangle there is a wide variation not only in fragment size, but also in the percentage of each size. Tables 1 and 2, which contain the results of mechanical analyses of the two tills and of water-laid sediments, show the great variation within the tills. Only samples which illustrate this variation are included in the tables. Stones larger than ½ in. in diameter were excluded from the mechanical analyses, and reference should be made to the field descriptions in the tables for indication of the stone content of the tills. Cumulative curves showing the grain-size distribution of many samples are also included for comparison (figs. 5, 6, 7, 12, 15). The figures in the right-hand column of tables 1 and 2 indicate the sorting coefficient of each sample; for explanation see footnote 3, table 1.

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[1] Cushman (1960, p. 109) stated that glaciofluvial deposits up to 20 ft thick are believed to overlie the floor of the buried channel of the Connecticut River in places. This is suggested by the fact that some wells drilled through unconsolidated sediments above the channel's bedrock floor yield water in considerable quantity. However, the samples of drill cores from this buried channel (fig. 3) were not available for examination by the author, and the interpretation from the driller's logs is that till, rather than water-laid material, overlies the bedrock. Samples from 32 boreholes along Highway I-91 and State Highway 3 were examined by the author; the deepest hole was 83.5 ft. All of these borings that penetrated to bedrock showed till between glaciolacustrine sediments and bedrock.

Table 1. Mechanical analyses of sediments[1]

Sample no.	Town	Location	Depth (ft)
24-54	New Britain	Northfield Rd. S of Cherryfield Dr.	4
25-54	New Britain	Northfield Rd. S of Cherryfield Dr.	10
27-54	Wethersfield	150 ft W of junction of Maxwell and Darwell Drs.	2
20-54	Wethersfield	Wells Rd. between Earl and Harold Sts.	5.5
21-54	Wethersfield	Wells Rd. between Earl and Harold Sts.	10
23-54	Wethersfield	Wells Rd. between Jay and Harold Sts.	9.5
28-54	Wethersfield	Wells Rd. and Silas Deane Hwy.	2.5
29-54	Wethersfield	Wells Rd. and Silas Deane Hwy.	4.5
2-54	Newington	500 ft SW of junction of Fenn Rd. and South Main St.	3
4-54	Newington	700 ft NW of junction of Church and Kelsey Sts.	4.5
16-54	Newington	200 ft SE of junction of Willard and Sunset Sts.	6
17-54	Newington	200 ft SE of junction of Willard and Sunset Sts.	9.5
31-54	Berlin	Selden Road, 1,000 ft S of Newington-Berlin Town Line	6
36-54	Hartford	1,000 ft W of W extension of Holcomb St.	5
35-54	Hartford	1,800 ft SW of junction of Princeton and Harvard Sts.	5
18-54	Hartford	1,800 ft SW of junction of Princeton and Harvard Sts.	3

[1] Stones larger than ½ in. in diameter were discarded before samples were analyzed by the writer; hence the curves (figs. 5, 6, 12) may differ somewhat from those based on other analyses.

[2] Diameters of the grain sizes are as follows: gravel, greater than 2 mm; sand, between 2 mm and 0.05 mm; silt, between 0.05 mm and 0.005 mm; clay, less than 0.005 mm.

Field description	Grain size[2] Gravel	Sand	(percent) Silt	Clay	Sorting Coefficient[3]
Silty till; moderately stony, pockets of sand and gravel	18	20	46	16	7.2
Gravelly, sandy till; many cobbles and boulders; shale bedrock at 11 ft	36	43	15	6	6.3
Gravelly till; 6 in. below contact with overlying gray sand	38	27	22	13	15.8
Clayey till; 4 ft above contact with 21-54	1	22	23	54	4.6
Varved clay; 6 in. below contact with 20-54	0	1	13	86	4.5
Stony till; 4 ft below contact with overlying varved clay (21-54)	43	27	18	12	10.0
Silty, clayey till; very few stones; 1 ft above contact with underlying silty, sandy till	2	3	16	79	3.1
Silty, sandy till; 1 ft below contact with overlying silty, clayey till	17	35	30	18	8.7
Silty till containing a few boulders; basalt at 5 ft	4	13	62	21	2.1
Silty till, bouldery; lenses of sand and gravel	8	20	44	28	3.9
Silty, clayey till; 3 ft above contact with 17-54	2	4	47	47	2.0
Clay (varved?) sample taken 6 in. below contact with 16-54	0	0	37	63	2.9
Clayey till; many angular to subrounded stones	1	16	18	65	4.9
Varved clay; fine-grained lamina	0	0	6	94	----
Varved clay; coarse-grained lamina	0	1	77	22	1.7
Silty, clayey till; 1 ft above silts and clays (varved?)	6	16	32	46	4.0

[3] The sorting coefficient is a measure of the uniformity of grain size in the particles making up a sediment. A sediment consisting of particles of equal size would have a sorting coefficient of 1. It is more exactly defined (Trask, 1932) as "$\sqrt{Q_3/Q_1}$ where Q_3 and Q_1 are the size values associated with the intersection of the cumulative curve and 75 percent and 25 percent values respectively."

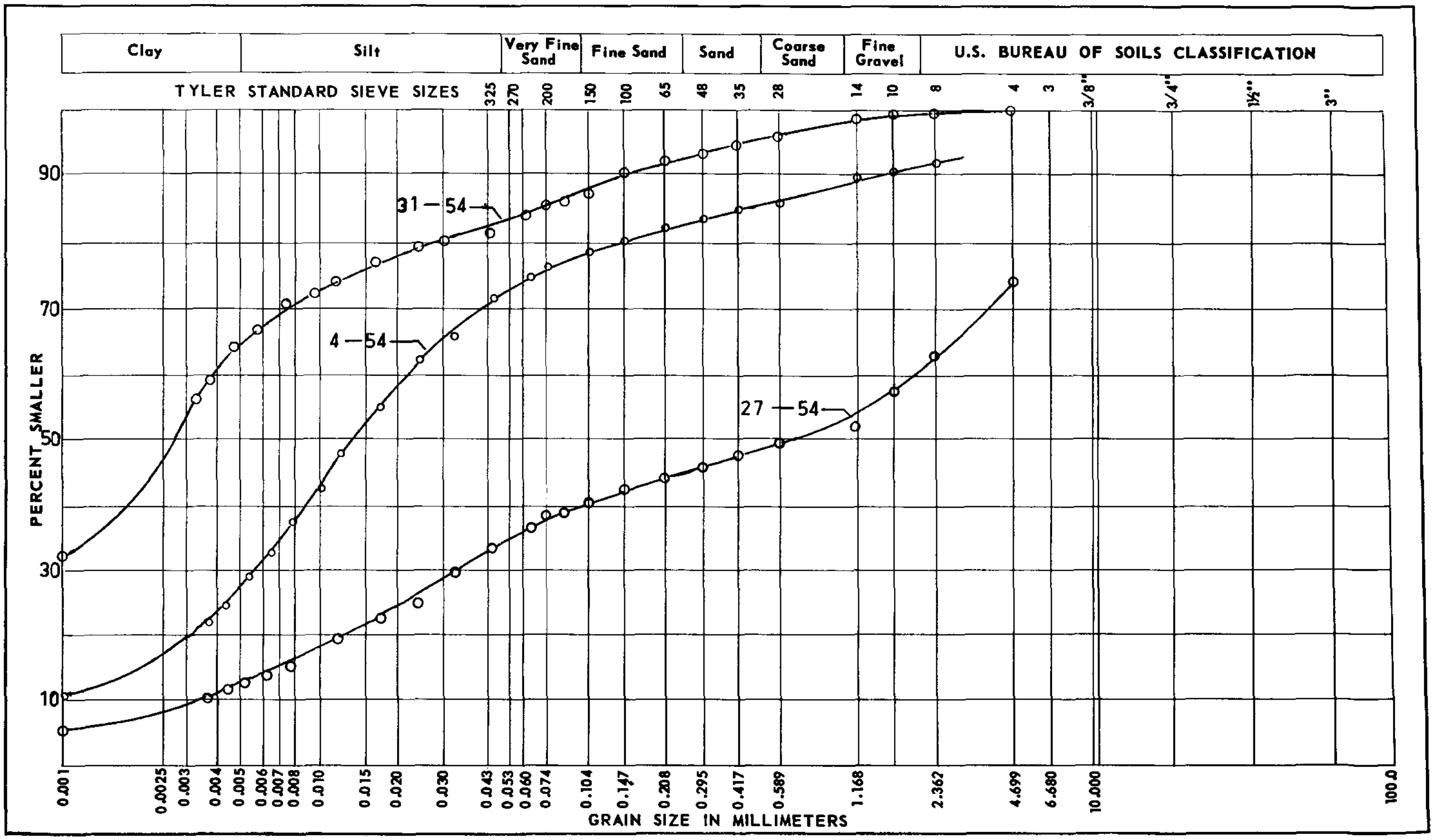

Fig. 5. Cumulative curves of samples from three tills. See table 1 for locations of samples. Sample 31-54 is a clayey till; 4-54 is a silty till; 27-54 is a gravelly till.

Two extreme types of till are common in the area: stony tills in which pebbles, cobbles, and boulders comprise as much as 50 percent of the material, and clayey tills containing more than 50 percent clay-sized particles. Between these two end members is a continuous series, probably the most common type being a compact, sandy till. The cumulative curves in figure 5 illustrate the variations in particle size in the Hartford South tills. Sample 27-54 is a stony till deposited close to bedrock outcrops and probably derived largely from the underlying rock. Sample 4-54 is a silty till which was reworked to some extent by meltwater prior to final deposition, as both the coefficient of sorting (3.9) and the field evidence indicate. Sample 31-54, composed of 65 percent clay, probably was derived from glaciolacustrine silt and clay when the glacier readvanced over these sediments. Samples 25-54, 23-54, and the bottom samples in both boreholes SD-14 and no. 3 (table 2) are other examples of stony tills with a very high coefficient of sorting; samples 24-54, 2-54, 11-54, 20-54, 28-54, and 18-54 (table 1) are other examples of silty or clayey tills which have a relatively low sorting coefficient.

The different types of tills are commonly separated from each other vertically by water-laid sediments, as illustrated in figures 6 and 7. In other places two varieties of till may be in contact vertically. Figure 8 and two pairs of samples in table 1 (24-54 and 25-54; 28-54 and 29-54) show this relationship.

The composition of the till commonly reflects that of the underlying bedrock. The rock fragments are derived almost exclusively from one or more of the Triassic sedimentary formations or from the lava flows. Generally, sedimentary rock particles predominate except very locally where trap is the underlying rock. Only the smallest fragments are composed of a single mineral; the others are sedimentary or igneous rocks, generally conglomerate, sandstone, or basalt. Fragments of crystalline rocks from the bordering Highlands (fig. 2) are rare. Shale and arkose commonly predominate in the coarse-sand size and may make up 50 percent of the grains present in the till, whereas grains composed of a single mineral become increasingly abundant as the size of the fragments decreases. Quartz, feldspars, micas, and clays are the most common minerals in the tills, with garnets and tourmalines the most common in the heavy fraction. Iron oxide is also abundant, particularly as a red pigment coating all particles in the till.

The character of till reflects the sort of material overidden by the glacier and incorporated into its basal load. In its advance and readvance along the Connecticut Valley the ice sheet overrode bedrock as well as the deposits laid down by a previous advance or by glacial meltwaters. Stony tills are common close to rock outcrops, particularly along the bedrock ridges, whereas clayey and silty tills are generally found associated with lacustrine clays and silts collected in depressions prior to the readvance of the ice. In many places the relationship of till to the material from which it is derived is clearly shown. The cumulative curves (fig. 6) of samples taken on Wells Road just west of Wolcott Hill Road (Wethersfield) show a basal till, sample 23-14, and an upper till, 20-54, separated by varved clay, 21-54. The high silt and clay

Table 2. Mechanical analyses of sediments[1] from boreholes

Borehole No. 3[2]

Depth range (ft)	Field description	Grain size[4] (percent) Gravel	Sand	Silt	Clay	Sorting Coefficient[5]
4-5	Sand, f to m	0	58	42		2.9?
10-11.5	Sand, f; trace gravel, f	3	88	9		1.7
16-17.5	Sand, m; trace gravel, m	7	89	4		1.7
25-26.5	Light-brown clay and silt; trace sand, f to c	0	12	24	64	?
30.5-32	Brown clay and silt; trace sand	0	5	31	64	7.1?
41-42.5	Reddish-brown clay and silt	0	7	29	64	7.7?
49-50.5	Reddish-brown silt and clay	0	51	21	28	4.1?
53.5-55	Reddish-brown gravel, f to c; some sand, f to c; little silt; trace of clay	53	34	7	6	5.2
62-62.5	Reddish-brown gravel, f to m; some silt; sand, f to c; trace of clay	47	26	19	8	14.6

[1] Data supplied by the Connecticut State Highway Department.

[2] Wethersfield; junction of Hwy. I-91 and State Highway 3 (Ramp Y over Hwy. I-91); Conn. Hwy. Dept.'s borehole location Y40 plus 20, 35 RT.

[3] Rocky Hill; junction of Silas Deane Hwy. and Hwy. I-91.

[4] Diameters of the grain sizes are as follows: gravel, greater than 2 mm; sand, between 2 mm and 0.05 mm; silt, between 0.05 and 0.005 mm; clay, less than 0.005 mm. Further size subdivisions are indicated by the following abbreviations: f=fine grained; m=medium grained; c=coarse grained.

[5] See footnote 3, table 1.

content (77 percent) of the upper till indicates that it was derived from the underlying glaciolacustrine sediments. Borehole SD-14 (table 2, fig. 7), located near the junction of Silas Deane Highway and Highway I-91, also shows this relationship. Varved clay occurs at depths of 25 to 30 ft in this drill hole. Samples to a depth of 25 ft show a wide variation in grain size. Samples from depths of 1 to 5 ft, 18 to 19 ft, and 23 to 24 ft suggest relationship to glaciolacustrine silts. However, the samples from 7 to 8 ft and from 24 to 25 ft show little such association. This variation in grain size is not exceptional and is often found in tills derived, in part, from previously deposited sediments. The sample from 40 to 41 is a typical basal till. The sample from 35 to 36 is not a basal till, and may indicate a minor readvance prior to the deposition of the varved clay. Good exposures of the upper till and the varved clay occur in a ditch on the south side of Highway I-91 just east of the Silas Deane Highway. Other examples of clayey and silty tills derived from glaciolacustrine sediments are north of Cedar Hill Cemetery in Hartford (table 1, sample 18-54) and in the Newington Road area just north of the Newington-West Hartford line.

Borehole SD-14[3]

Depth range (ft)	Field description	Grain size[*] Gravel	Sand	(percent) Silt	Clay	Sorting Coefficient[5]
1-5		8	12	28	52	3.2
7-8		18	19	38	25	8.9
11-12		3	9	50	38	3.3
15-16	Reddish-brown silt and clay with traces of sand and gravel; some varves and distorted laminae	10	12	45	33	3.7
16-17		8	9	51	32	2.9
18-20		6	14	56	24	2.6
22-23		25	28	32	15	12.4
23-24		2	10	39	49	9.4
24-25		34	22	27	17	20.8
32-33		12	15	39	34	4.7
33-34	Reworked till	16	22	25	37	9.1
35-36		18	21	21	40	12.2
40-41	Basal glacial till	54	24	10	12	23.7
45-47		40	25	15	20	23.6

The tills within the quadrangle are characteristically reddish (stony and sandy tills) or brownish (clay tills) due to iron-oxide stain and the presence of fragments of Triassic sedimentary rocks.

The topography on the tills described above is gently rolling. The top 1 to 3 ft in places consist of till that contains much less clay and silt than the till beneath it. This veneer generally is the sandy to gravelly residue of the drift from which the fines were washed away during the final stages of melting. The remaining till occurs in drumlins.

A very gravelly type of till is associated with the glaciofluvial sand and gravel in the area along the Wilbur Cross Highway from the Mattabesset River (Berlin) to Cedar Street (Newington) and in the vicinity of Dividend Pond (Rocky Hill). This till forms scattered and irregular cappings 2 to 8 ft thick over glaciofluvial material. Its lack of stratification is in distinct contrast to the well stratified sand and gravel beneath it. The till is moderately well sorted, containing only minor amounts of clay and boulders. It may, in some instances, represent a minor readvance of the ice over glaciofluvial deposits—if so, the glacier picked up some sand and gravel and redeposited it. Some of the till, on the other hand, may be flowtill (Hartshorn, 1958); in this case it is a deposit from stagnant ice. Some of it may not be till at all, but may have resulted from soil creep or solifluction. Washburn (1947, p. 48) has described the similarity between solifluction deposits and till.

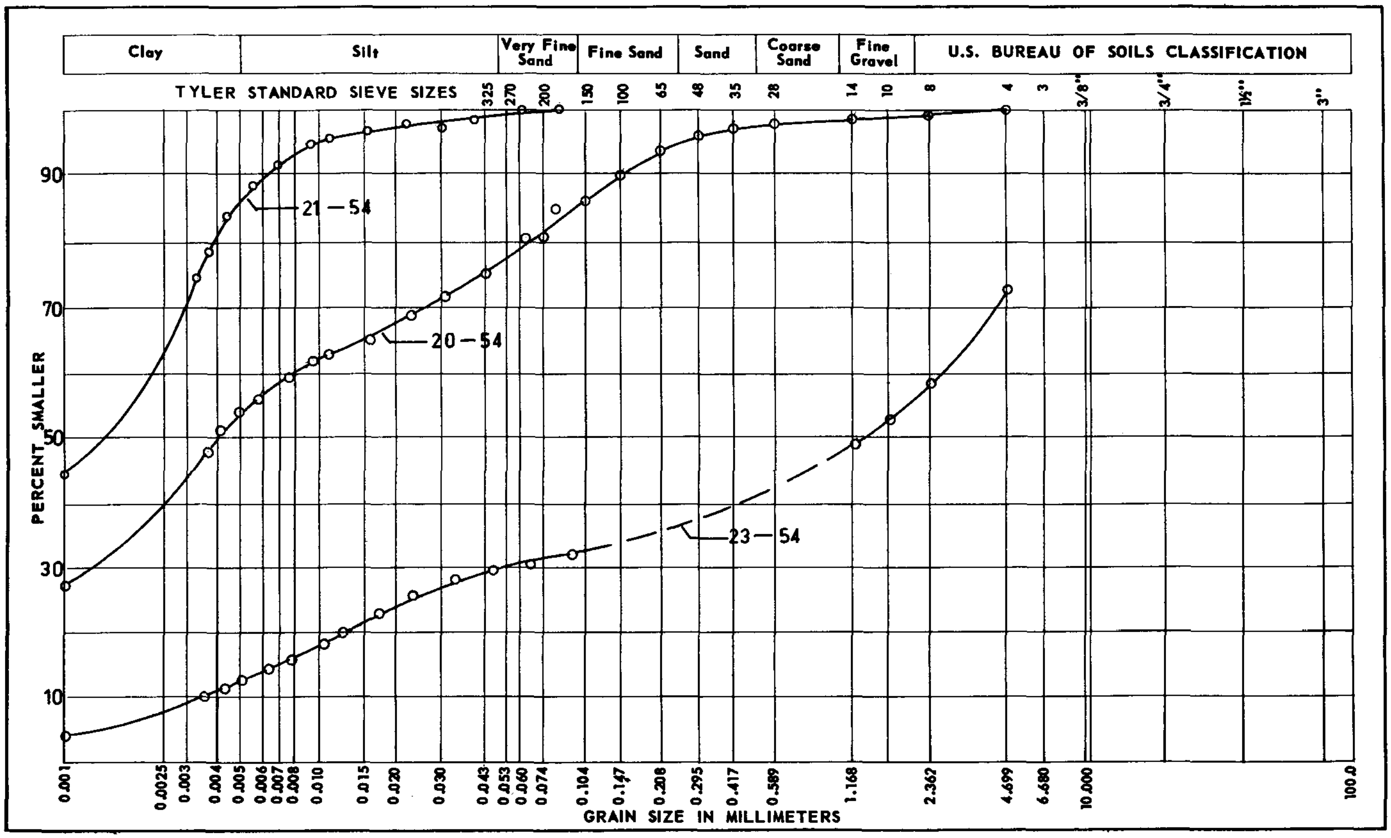

Fig. 6. Cumulative curves of samples from two tills separated by a varved clay. See table 1 for location of samples. The sample of varved clay (21-54) was taken 6 in. below the contact with overlying clayey till (20-54). The sample of stony till (23-54) was taken 4 ft below the contact with overlying varved clay.

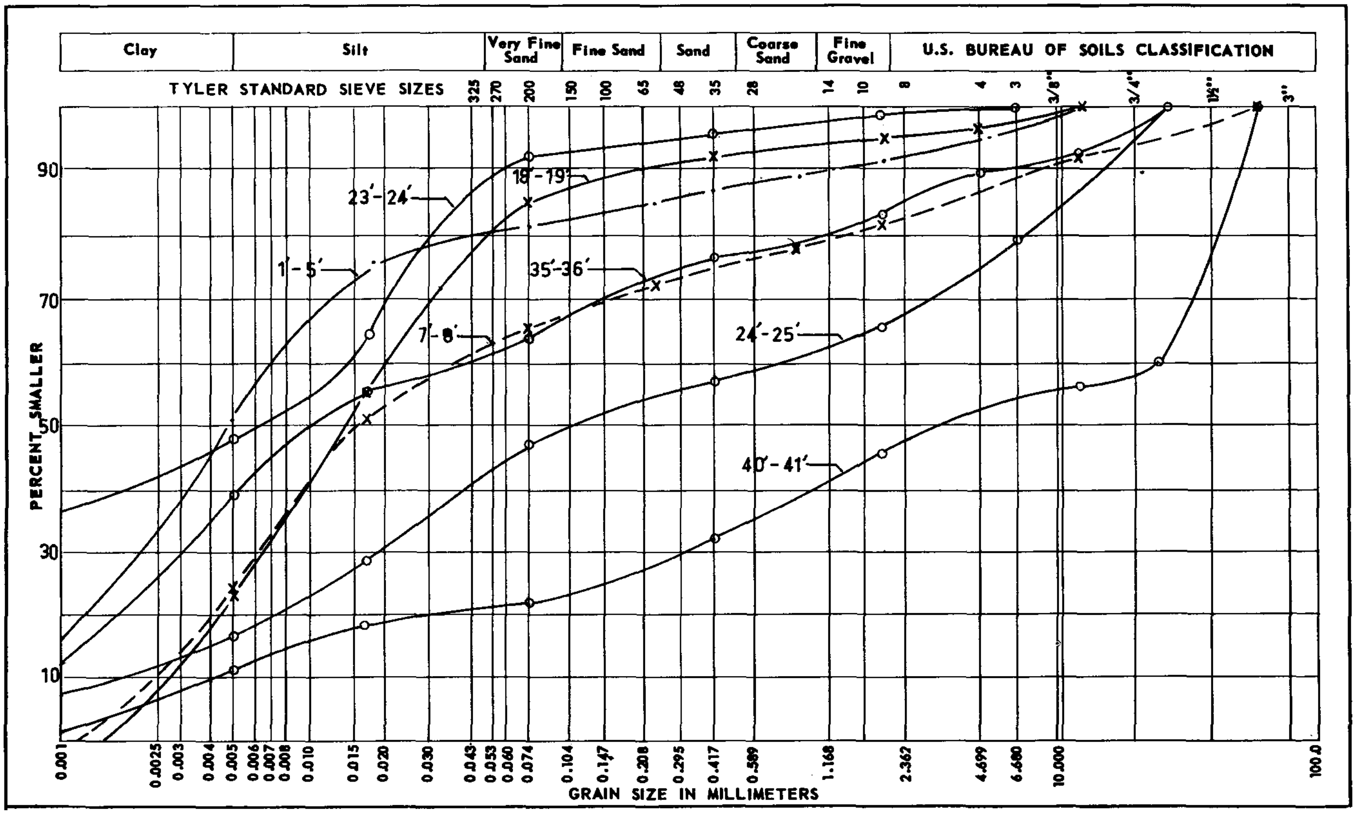

Fig. 7. Cumulative curves of a suite of samples from borehole SD-14. See table 2 for location of samples. Samples are identified by depths in ft in borehole; those from 1 to 25 ft are from a till that overlies varved clays which are at depths of 25 to 30 ft; those from 35 to 41 ft are from the till underlying the varved clay. Analyses supplied by the Connecticut State Highway Department.

Fig. 8. A silty till, derived in part from varved clay, and overlying a compact sandy till; junction of Cedar and Willard Streets, Newington.

Boulders, partly or completely exposed on the till surface, are common in some parts of the area, particularly on Vexation Hill and on the ridge south of Little Brook (Rocky Hill) and, to a lesser extent, on Cedar Mountain (pl. 1). The boulders are about evenly divided between basalt and sedimentary rocks. Many trap boulders rest on sedimentary outcrops, and sedimentary boulders lie on igneous outcrops. Although they are erratics, they are considered to be of local origin, and have not been transported far. The largest boulder seen in the quadrangle is 12 ft in diameter, small compared to those reported from nearby quadrangles (Porter, 1960, p. 12; Flint, 1962, p. 11; Hanshaw, 1962).

GLACIOFLUVIAL DEPOSITS

Meltwater-stream deposits of sand, gravel, silt, and clay, in order of decreasing abundance, are widespread, covering nearly a quarter of the surface of the quadrangle. The two largest deposits are in the southeastern corner and in the western part extending from the Mattabesset River northward to the Newington-West Hartford Town Line. Isolated patches are found along Little Brook and the small stream south of it, near West School (Rocky Hill), west of Newington Junction, and in the southwestern corner of the quadrangle.

Some of the sediments were deposited in immediate contact with ice and possess some or all of the characteristic ice-contact features (Flint, 1957, p. 146), such as relatively poor sorting, abrupt changes in grain size both vertically and horizontally, included masses of till, and collapsed or deformed bedding. Other stream deposits exhibit none of these features. In some places sediments with ice-contact characteristics were seen to grade into others that lack these features. It was found impractical to map these two types of glaciofluvial sediments separately for this report because of the lack of complete and continuous exposures. Moreover, some of the stratified sediments show deltaic structures, a transition feature between stream and lake deposits.

The glaciofluvial deposits in the quadrangle vary greatly in structure and texture but are fairly uniform in composition. The wide variation in grain size from clay to boulders several feet in diameter indicates a great variation in stream conditions. The transportation of the numerous cobbles and boulders and the thick beds of coarse gravel required strong currents. However, the fine- to medium-grained sand which constitutes the bulk of the material in many localities suggests that stream velocities generally were not high. Silt and clay are present, but make up only a small percentage of the material. These fines do not necessarily indicate low stream velocities because a rapidly flowing, mud-laden stream deposits fine material in the interstices between the sand and gravel in its bed. On the other hand, where beds of fine sand and silt are found, deposition in temporary ponds dammed by wasting ice or in very slowly flowing rivers is suggested. In many localities foreset bedding overlain by topset bedding indicates deltaic deposition in temporary lakes. Abrupt changes in prevalent grain size resulted from sudden changes in current direction or velocity. At most excavations grain size increases upward. This implies that as the stream or lake bed filled, stream velocity increased. Thick beds of material of uniform size suggest rapid deposition during periods of uniform conditions. Many changes in stream direction are inferred from the infinite variation in the direction of fluvial cross bedding. Although at various times the streams flowed temporarily in many different directions, a general southward flow predominated.

Stream flow was uniform in both direction and velocity in some areas. A pit south of Brook Street (Rocky Hill) exposed uniform cut-and-fill stratification and cross bedding in well sorted, coarse sand and fine gravel (fig. 9).

Ice-contact features are abundant in the meltwater-stream deposits north of the Mattabesset River in the vicinity of the Wilbur Cross Highway, and in the area south of Rocky Hill and east of Highway 9 (fig. 10). Such collapse phenomena as the reversal of cross bedding, oversteepening or folding of bedding planes, and small faults are common. These features probably are the result of melting of the ice beneath or adjacent to the sediments. Some of these features may have been caused by a slight readvance of the ice against which the sediments had been deposited. A readvance, perhaps of minor proportions, is indicated by some of the till that overlies the stream deposits. An exposure south of the junction of Main Street and the Wilbur Cross Highway (Newington) shows foreset beds, the upper parts overturned and overlain by 5 ft of gravelly till. The till masses found in many places within the fluvial deposits may have been laid down by readvancing ice, but, like some of the till-like cappings, they may be flowtill or some other material.

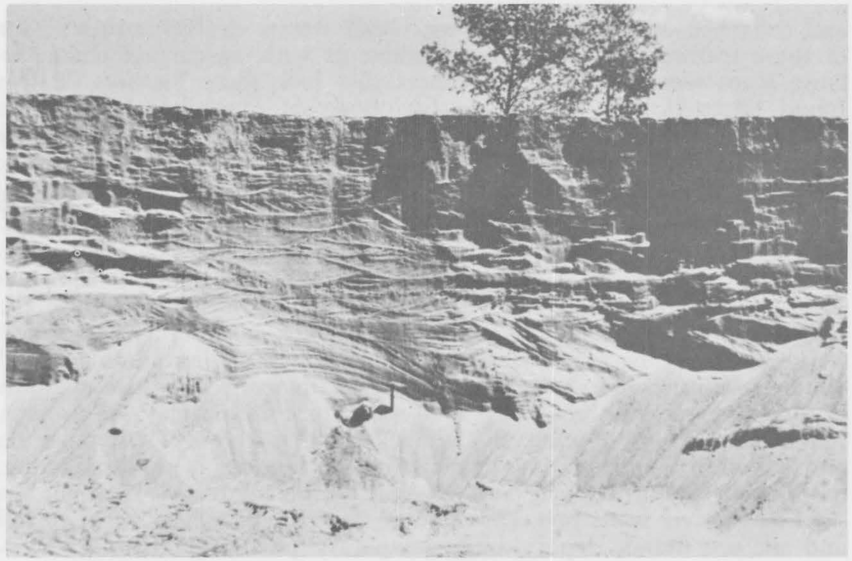

Fig. 9. Cut-and-fill features in outwash sand and gravel in pit east of Cromwell Avenue and south of Brook Street, Rocky Hill.

The components of the stream deposits are only moderately rounded, suggesting brief transport by water. They were probably derived in part directly from the drift in the ice and in part from the erosion of other unconsolidated deposits, either at the base of the ice or along stream banks. In any case, the stones had been transported prior to their incorporation in the stream load. Erosion of bedrock by glacial streams in spillways appears to have been slight.

The composition of the meltwater-stream deposits is not unlike that of the till. The boulders, cobbles, and pebbles are of basalt and local sedimentary rocks. Shale fragments make up a large part of the sand-sized fraction. Mineralogically, the sand-sized particles show derivation from both adjacent lavas and the red beds. Metamorphic minerals common to the crystalline rocks of the bordering Highlands are present also, but this is to be expected, as the Triassic sediments were derived from these older rocks.

The color of the glaciofluvial deposits, particularly those having ice-contact characteristics, is generally reddish brown. This color may be due to the relatively high content of clay-sized particles which are invariably reddish brown in the ice-contact deposits of this quadrangle. The Pleistocene clays within the quadrangle are also invariably reddish brown. The silt beds are generally light brown, although individual strata of sand are in places gray to grayish brown. Those sand and fine-gravel layers which are more uniformly bedded and sorted tend toward a buff color. Manganese oxide coats many of the pebbles in the gravel beds, giving the stones a purplish-black sheen. In addition, iron oxide coats most fragments. Weathering rinds up to a quarter of an inch thick characterize some of the pebbles and cobbles.

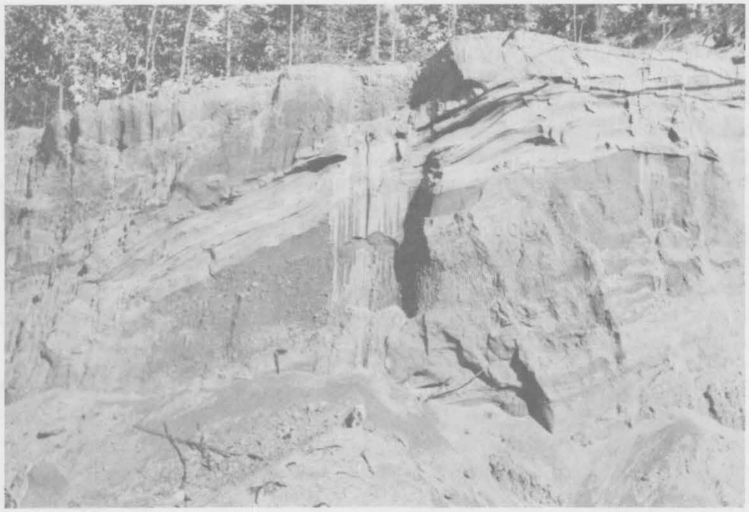

Fig. 10. Glaciofluvial sand and gravel showing ice-contact features. In pit south of Dividend Pond, Rocky Hill.

In many cases the thickness of the glaciofluvial deposits cannot be determined. Most wells drilled into them encounter water above the base of the deposits and are therefore drilled no deeper. Many gravel pits are not excavated below the water table; others reach fine material within the stream deposits, making deeper digging unprofitable. In the Wilbur Cross Highway area the sand and gravel workings are all less than 50 ft deep. In 1962, however, a section in a pit north of Dividend Pond showed an uneven surface of bedrock and bouldery till beneath about 90 ft of sand and gravel; several other excavations in the same area expose approximately the same thickness.

Adjacent to the Mattabesset River and south of the village of Newington the glacial stream deposits become finer at depth and in places grade into varved clay. Varved clay also underlies two other small areas, one along the southern edge of the map (pl. 1) west of Cromwell Avenue, and the other east of the Veterans Home in Rocky Hill.

The maximum elevation of the glaciofluvial deposits in the quadrangle is about 175 ft above sea level, except for the section at the head of Little Brook and the small deposit at West School (Rocky Hill) which reach an altitude of nearly 200 ft.

The physiographic forms of the stream sediments are varied. Those of the Wilbur Cross Highway area are the most complex. There, although the irregular knob-and-kettle topography suggests an end moraine, it is considered to be a kame moraine because the material is mainly sand and gravel rather than till. Kettles, depressions formed when buried blocks of ice melted, are present, but they are neither common nor large. Kame terraces, flat-topped, narrow deposits of sand and gravel laid down between the ice and valley walls, lie along the western flank of Cedar Mountain. Similar deposits at the Crippled Children's Home and along the Wilbur Cross Highway just south of Robbins Avenue, both in Newington, may also be kame terraces. The tops of the hills, at a general elevation of about 160 ft, may be remnants of a kame plain which was built up between masses of ice to an elevation above the general level of the surrounding ground. How much of the material between the hills was originally deposited on ice and subsequently collapsed to its present elevation is not known; collapsed bedding, however, is common. Those deposits clearly showing foreset bedding were laid down as deltas in temporary lakes. In the Wilbur Cross Highway area the deltaic sediments show many ice-contact features and are considered to be kame deltas. Some of the isolated hills of sand and gravel may be kames.

The sinuous ridge just north of Highway 72 and west of the Wilbur Cross Highway may have been an esker; exploitation for sand and gravel between 1954 and 1962 removed this feature. Another sinuous ridge, cut in two by a modern stream, lies east of Churchill Park (Newington) and extends north from the Wilbur Cross Highway for slightly more than half a mile.

In the southeastern part of the quadrangle the sand and gravel on the west side of the Connecticut River have ice-contact features and the form of a kame terrace or a kame plain. The Mustard Bowl and several other depressions in the Edgewood Country Club grounds (south and west of Dividend Pond) are among the largest kettles in Connecticut. The irregular topography of the kame type of deposit here gives way westward into level ground suggestive of an unpitted outwash plain at a general altitude of about 150 ft.

The glaciofluvial sand and gravel west of Newington Junction is part of a kame delta that extends into the New Britain quadrangle (Simpson, 1959). The sediments in the valley of Little Brook and in the stream valley south of it are valley-train deposits, long, narrow bodies of outwash confined within a valley.

GLACIOLACUSTRINE DEPOSITS

Sediments deposited on the floors of glacial lakes, or along their shorelines, do not lie at the surface over a very large area of the quadrangle. However, these deposits are widespread beneath later ones and are of economic importance, particularly in ground-water and engineering studies. Their subsurface extent is therefore indicated on the map (pl. 1).

Glacial-lake deposits include three distinct types of material, determined by place of distribution. Sand and gravel mark the periphery of a former lake. Fine gravel, coarse to fine sand, and silt lie between the shoreline and the deeper parts of the lake. Varved clay fills the lake-floor depression and is the most widespread of the three types. All gradations exist between these three distinct types of lake sediment, and in some places they grade into glaciofluvial deposits.

Varved clay deposits[2] are rhythmically banded sediments composed of successive pairs of laminae, each pair being made up of a relatively coarse-grained, light-colored, lower lamina and a fine-grained, dark-colored, upper lamina. The lower lamina is mainly silt (table 1, sample 35-54) whereas the upper one is predominantly clay (table 1, sample 36-54). The coarse-grained layer is generally the thicker, and the thickness of the varves generally decreases upward.

Well laminated varved clay is rarely exposed at the surface. In many places the varves are overlain by silty and clayey till or by alluvium. In other places the varves grade upward into lacustrine silt and sand. Where varved clay is not overlain by later sediments, weathering usually destroys the varving to a depth of 2 to 4 ft. There are natural exposures of varved clay along some of the stream banks within the quadrangle, but most evidence of the deposits was obtained from artificial exposures and drill holes.

Two types of varved clay are found within the quadrangle. The older of the two, herein called the Berlin Clay[3], includes all those clay and silt deposits possessing similar characteristics (see table 3), even though no known connection existed between the bodies of water in which they were laid down. The Berlin Clay was deposited in quiet water bordering the irregular front of stagnant ice. This proximity to the ice is indicated where the sediments were overridden during a re-advance of the glacier. Evidence of the overriding is seen in many places where it deformed the upper part of the deposit (fig. 11) or where the overlying till is derived largely from underlying varved clay. The cumulative curves in figure 12 show the similarity in grain size between composite varved clay (sample 17-54) and overlying till (sample 16-54) derived from it. The sediment is generally rich in clay, as shown by the composite samples 17-54 and 21-54 of table 1.

A small area of Berlin Clay lies along the southern edge of the quadrangle west of Cromwell Avenue and east of Highway I-91. Along the Mattabesset River and Webster Brook is a portion of a large deposit that extends into the Middletown, New Britain (Simpson, 1959) and Meriden (Hanshaw, 1962) quadrangles. A large area of the Berlin Clay extends through the central part of the Town of Newington and northward into West Hartford. Narrow bands are found also in the central sections of the Towns of Hartford and Wethersfield and in the eastern part of Rocky Hill.

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[2] The term *varved clay* is used in this report although silt and sand may exceed clay in many of the deposits to which the term is applied in the Hartford South quadrangle. Also, the clay here may not be truly varved in the sense that annual deposition of a varve-forming pair is implied. The term, however, has been accepted too long and has been too well integrated into the literature to be abandoned in favor of other terms not so widely accepted. *Varved clay* as here used is synonymous with rhythmically laminated clay and silt (Porter, 1960, p. 18), fine-grained cyclic sediments (Simpson, 1959), and rhythmites (Flint, 1959, p. 293).

[3] The Berlin Clay of this report includes the Middletown Clay and the Berlin Clay as well as the Clayton Clay of Flint (1933).

Table 3. Comparison of Berlin Clay and Hartford Clay

	Berlin Clay	Hartford Clay
Color	Deep reddish brown throughout	Gray on top; reddish brown at depth
Texture	Clay predominates	Silt and fine sand predominate
Structure	In many places folded in upper part (fig. 11)	Never folded; may show minor faulting
Concretions	Reddish brown, irregular large (up to 6 in. long)	Gray, flat, symmetrical, small (less than 2 in. long)
Relation to till	Ordinarily overlain by till (fig. 11); fragments of varves found in overlying till	Never overlain by till
Occurrence	Found in scattered localities throughout the area	Confined to area of Lake Hitchcock
Thickness	Generally thick; rarely less than 2 in. per varve (fig. 11)	Generally thin; decreases to ⅛ in. per varve (fig. 13)

The younger silt and clay (fig. 13), herein called the Hartford Clay, forms a more continuous deposit which can be related to a single glacial lake, Lake Hitchcock (Lougee, 1939). This clay is also very limited in surface exposure. Throughout much of the area shown on the map (pl. 1) it is overlain by glaciolacustrine or glaciofluvial sand or by postglacial sediments. The largest area of Hartford Clay lies close to the Connecticut River channel, extending from the northern edge of the quadrangle southward into Rocky Hill. Smaller areas of the clay are in the vicinity of Folly Brook (Wethersfield), the south branch of Park River (Hartford and West Hartford), and Mill Brook (Newington).

The Berlin Clay and the Hartford Clay are quite unlike, as shown in table 3. However, certain similarities exist: both clays contain pebbles and concretions, more commonly in the coarse-grained laminae; both may be overlain by unlaminated clay and silt (in the lower varved clay this material is difficult to distinguish from the overlying till); in places both clays grade upward into silt and sand.

Exposures that clearly show the relationship between the Berlin Clay and the Hartford Clay have not been seen in the quadrangle. Varved clays that are unmistakably Hartford Clay have not been observed to overlie directly varved clays that are undoubtedly the Berlin Clay. However, numerous borings have penetrated through the Hartford Clay, into an underlying silty clay till and into a varved clay which is here called the Berlin Clay (figs. 3, 4). The transition in color of the Hartford Clay from gray to reddish brown is well documented in borehole data (fig. 2).

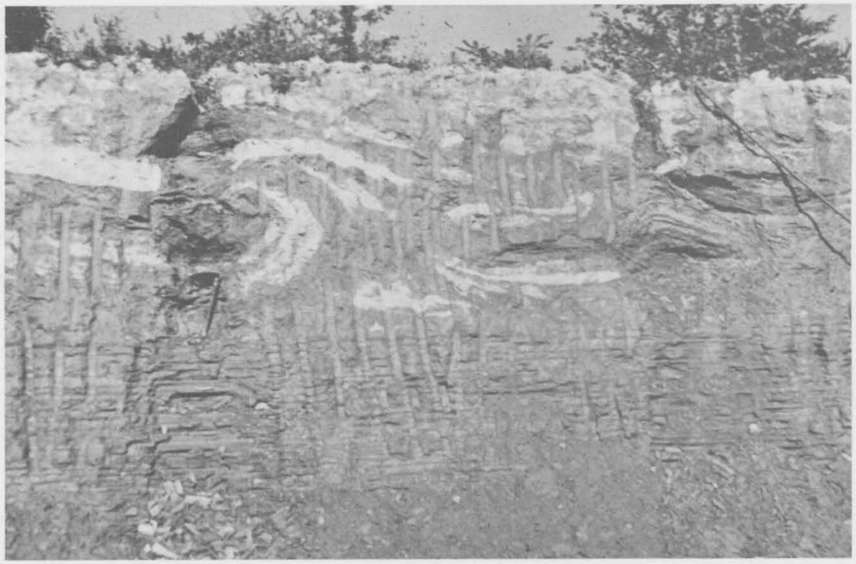

Fig. 11. Varved-clay till and folded sediments overlying undisturbed lower varved clay deposit. In Donnelly Brick Yard, Berlin.

Both varved clays are extremely variable in thickness. The thickest sections are, however, invariably between bedrock or till ridges and wedge out laterally against the ridges, being absent from the ridge summits. The thickest known section is in the bedrock valley of the Connecticut River in the Keeney Cove area of East Hartford and Glastonbury Townships, where approximately 165 ft of the total section of sediments (255 ft) is varved clay.

Beach sand and gravel of glacial Lake Hitchcock are found in several localities in the northern half of the quadrangle. They form narrow terraces along parts of the shoreline and also occur as thin cappings over areas that emerged as islands during the lowering of the lake. The shoreline deposits were controlled largely by topography, and formed only where the fetch of the lake was sufficient to develop waves capable of concentrating gravel.

The longest beach deposit lies along the crest of the basalt ridge extending half way across the map from Trinity College (Hartford) on the north border southward to Goff Brook (Wethersfield). Another beach is between the Silas Deane Highway and Wolcott Hill Road in Wethersfield. Smaller deposits lie east and west of Trout Brook (West Hartford) and east and west of Newington Junction, on Cedar Street west of Willard Street, and south of Robbins Avenue, all in Newington.

The shoreline deposits are thin, generally less than 5 ft thick. In places the deposits shown on plate 1 are only about a foot thick and normally would not be mapped. They are included in order to outline the limits of Lake Hitchcock. The material is predominantly medium

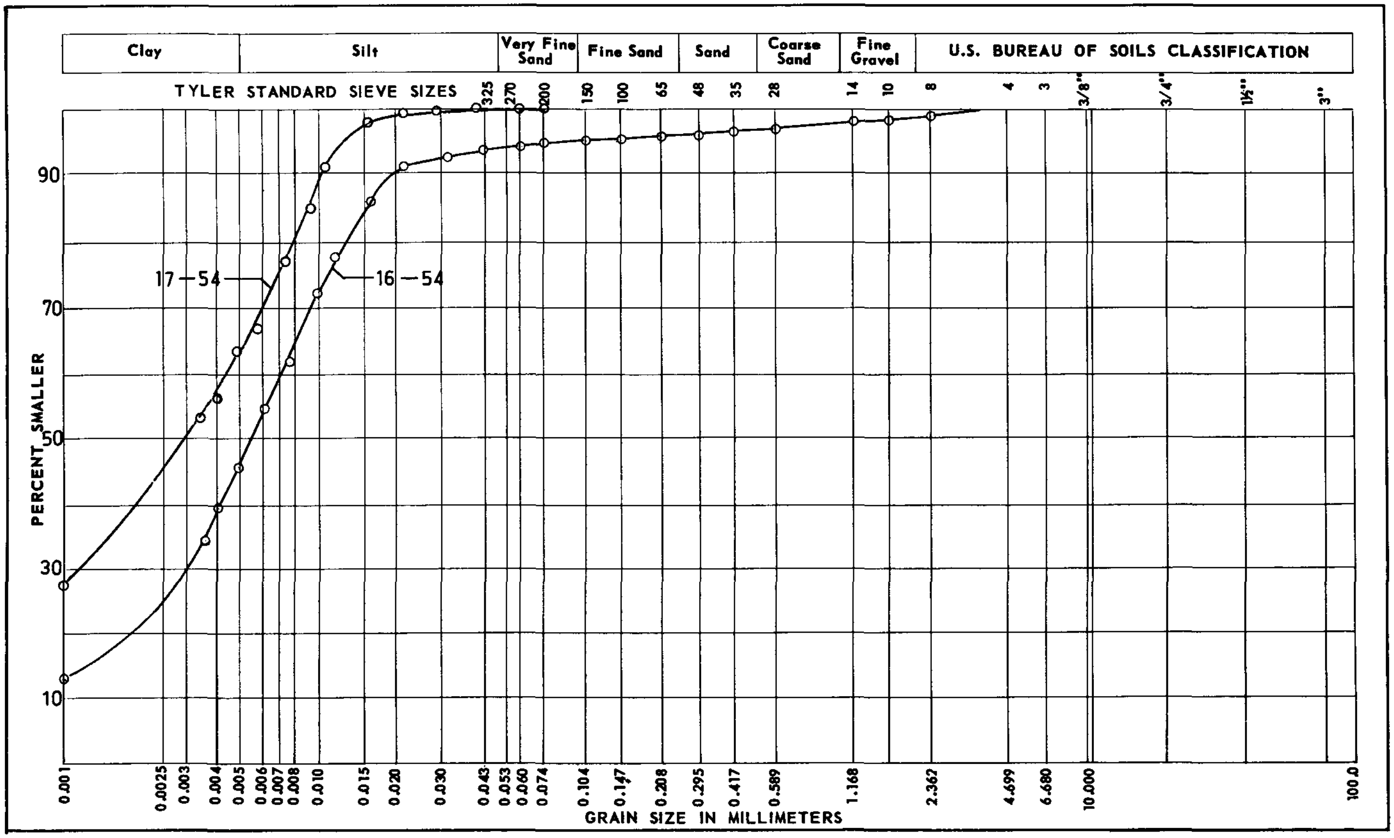

Fig. 12. Cumulative curves of samples from a silty clayey till (sample 16-54) and an underlying (varved?) clay (sample 17-54). See table 1 for location of samples. Sample 16-54 was taken 3½ ft above sample 17-54.

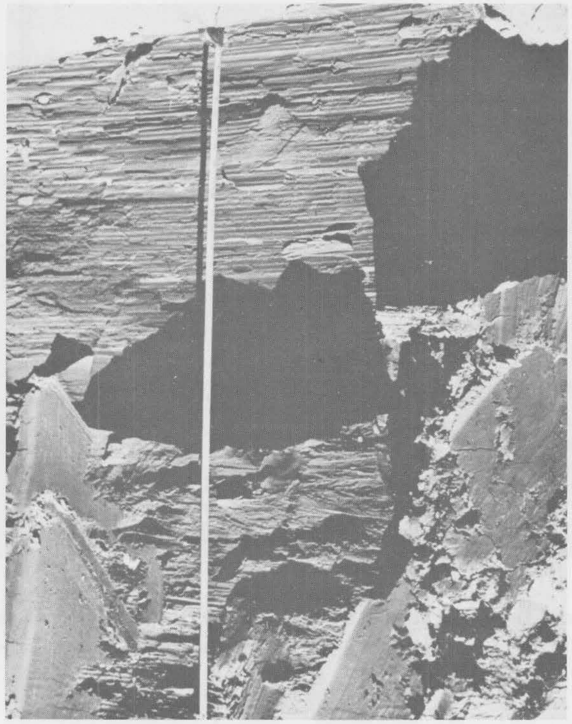

Fig. 13. Hartford Clay. Compare the thickness of the varves with those in figure 11. At intersection of Wethersfield Avenue and Airport Road, Hartford.

to coarse gravel with minor amounts of sand (fig. 14). The pebbles are subangular to subrounded and in places consist chiefly of shale and sandstone chips with an imbricate structure. The gravels are poorly stratified and the bedding dips toward the lake.

The maximum altitude of the beach gravel is 160 ft. That south of Trinity College is persistent along the 150-ft contour and extends in places down to about the 80-ft contour.

Shore bluffs, characteristic of many lakes, are lacking in the Hartford South quadrangle. Together with the poor development of beach gravel around the periphery of the lake and the poor rounding of the pebbles, this suggests that Lake Hitchcock was short lived or at least did not remain at any one level for very long.

Intermediate between the shoreline gravels and the deep-water deposits of varved clay are shallow-water deposits of fine- to medium-grained sand with minor amounts of silt and gravel. The excellent sorting characteristic of this sediment is illustrated by the cumulative curve of the sample taken from 16- to 17.5-ft depth in bore hole no. 3 (fig. 15). These sediments grade downward into varved clay in the deeper parts of the lake basin, but in the shallow parts the contact between the clay

Fig. 14. Beach gravel of Lake Hitchcock overlain by 2 to 3 ft of sand. Note the angularity of the pebbles. Along West Hartford-Newington Town Line 200 ft west of South Main Street, West Hartford.

and the coarser sediments may be unconformable, due to wave action when the lake was at its maximum or when it was receding. Some of the sand is probably deltaic, particularly that at Elmwood in West Hartford. The lacustrine silt, sand, and gravel deposits associated with the Berlin Clay are ordinarily reddish brown, whereas those overlying the Hartford Clay are generally gray to grayish brown, except where they have been oxidized to a light-brown color. The glaciolacustrine sand ,is rarely more than 30 ft thick in the deeper parts of the lake basin and wedges out toward the shorelines. In many places sand is altogether lacking.

The stratified sand, silt, and gravel referred to in the above paragraph occur in some parts of the central and northern portions of the quadrangle between about 45 ft above sea level and the shoreline of Lake Hitchcock. These deposits have been mapped as glaciolacustrine material rather than as terrace alluvium or as stream terrace deposits. The width of the body of water indicated by these deposits is more characteristic of a lake than of a stream. Table 4 shows the width of the part of the southern end of Lake Hitchcock which was confined to the Rocky Hill outlet as the water dropped to various levels. In the southern part of the quadrangle, however, pronounced stream terraces are found at an altitude of approximately 60 ft on both sides of the Connecticut River. Here the water at the outlet was confined to a width of less than one mile, in contrast to the greater widths farther north as shown in table 4. Because of this constriction, currents were produced that were capable of cutting terraces.

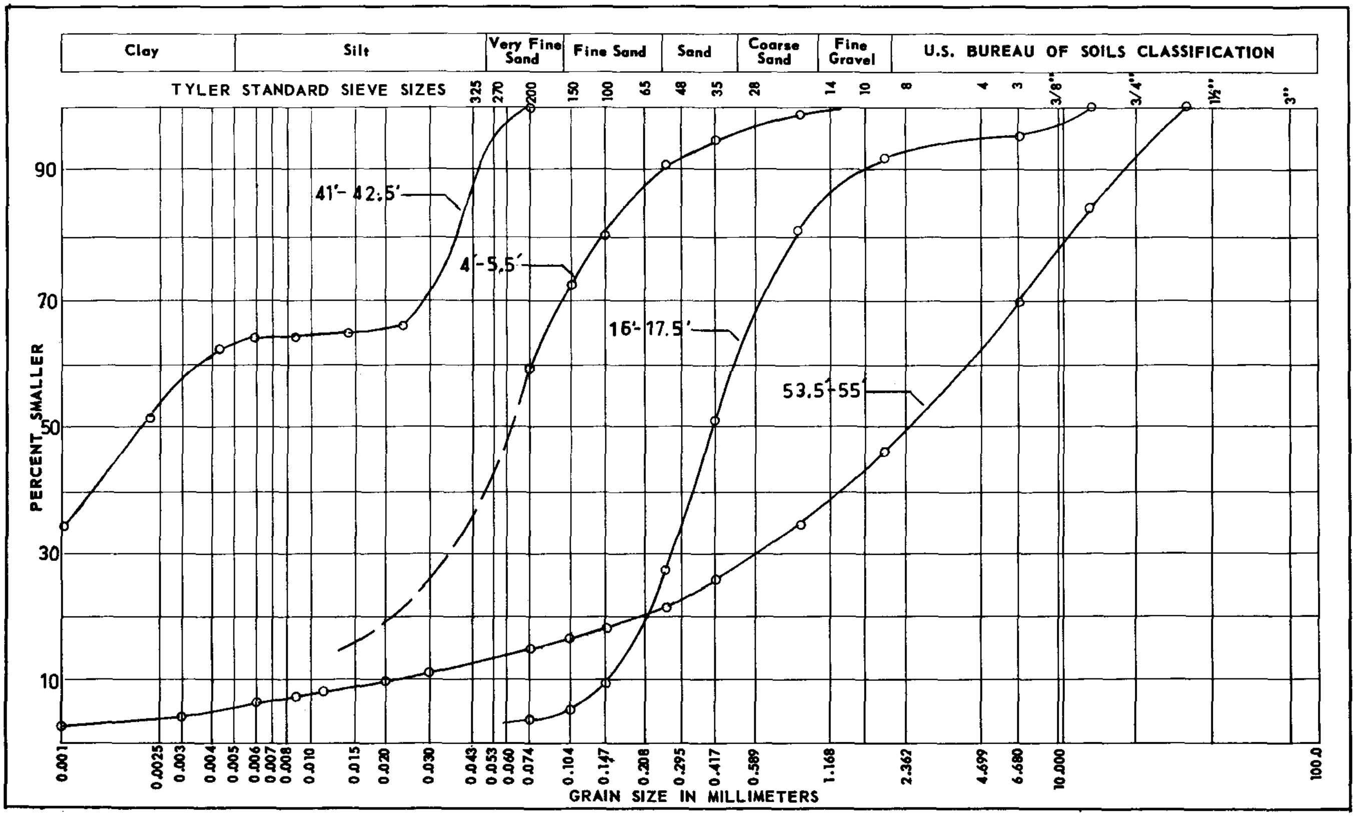

Fig. 15. Cumulative curves of a suite of samples from borehole no. 3. See table 2 and figure 4 for location of samples. Samples are identified by depths in ft in borehole; 4 to 5.5 ft is terrace-alluvium sand, 16 to 17.5 ft is glaciolacustrine sand, 41 to 42.5 ft is varved clay, and 53.5 to 55 ft is basal till. Analyses supplied by Connecticut State Highway Department.

Table 4. Width of Lake Hitchcock at various levels

Level (ft)	Width (mi.)[1] South Wethersfield	Wethersfield Cove	North line of quadrangle
130	4.4	4.7	6.3
110	4.3	4.6	5.7
90	3.8	4.4	4.4
70	3.0	3.6	3.8

[1] The widths given here include the part of the lake to the east in the Glastonbury quadrangle.

Postglacial deposits

GENERAL REMARKS

Deglaciation of the Hartford South quadrangle was gradual. The division between glacial and postglacial time is, therefore, arbitrary and is here considered to coincide with the disappearance of the ice from the general area. Water, wind, gravity, and various organisms (including man) have continued to modify the glacial landscape into its present form, both by erosion and deposition. The chief postglacial deposits are terrace alluvium, alluvium, sliderock, swamp deposits, wind-blown deposits, and artificial fill.

TERRACE ALLUVIUM

Relatively flat, steplike, narrow plains rise above and adjoin the modern floodplain of the Connecticut and Mattabesset Rivers. The material of these narrow belts has been mapped (pl. 1) as terrace alluvium. Along the Connecticut River the lower limit of the terrace alluvium is about 20 ft above sea level, rising to about 45 ft altitude in the central and northern parts, and to nearly 60 ft in the southern part of the quadrangle. In the southwestern part terrace alluvium associated with the Mattabesset River and with Piper Brook extends from about 30 ft to a little over 60 ft above sea level. Along both rivers this terrace sediment varies from about 1 ft to nearly 10 ft in thickness but is more commonly 4 to 5 ft thick.

The terrace alluvium consists mainly of sand-size particles with some silt and pebbles and shows excellent sorting (fig. 15, sample from 4 to 5.5 ft). The material lies within the zone of intense oxidation and hence is generally yellowish brown in color. The composition is similar to that in the underlying till, glaciofluvial, or glaciolacustrine deposits. In all probability the terrace alluvium has its source in one or more of these older deposits. Although in the East Berlin area along the Mattabesset River it is probably in direct contact with varved clay, it does not appear to be so in areas adjacent to the Connecticut River.

The terraces have been formed, in part at least, as a result of downcutting by the rivers as they meandered over their valley floors. The alluvium on these terraces was deposited by these rivers. The elevated isolation of the terraces reflects continued downcutting by the rivers in the more restricted area of the present floodplains.

ALLUVIUM

Alluvium consists of sediments laid down by present-day streams. The Connecticut River alluvium is far more extensive than that of all the other streams in the quadrangle combined. In the northwestern part of the quadrangle, the south branch of Park River and its two tributaries, Trout Brook and Piper Brook, have limited alluvium deposits. The Mattabesset River, in the southwestern part of the quadrangle, also has a small deposit of alluvium on its floodplain. Alluvium is too restricted to be mappable on plate 1 along any of the other streams in the quadrangle except along Dividend and Goff Brooks.

Alluvium is deposited both in the beds of streams and on their floodplains. Floodplains are flat surfaces which, in most places in the quadrangle, are the eroded surfaces of older deposits of either glaciolacustrine or glaciofluvial origin. At a few localities, such as along Highway I-91 south of Wethersfield Cove and beside the Mattabesset River where it has cut through the basalt ridge northeast of Berlin, alluvial sediments lie on till or bedrock.

Alluvium thick enough to be a mappable unit in the Hartford South quadrangle is generally restricted to areas below about 20 ft above sea level. The profile along State Highway 3 (fig. 3) shows the floodplain of the Connecticut River at about 16 ft altitude, separated from the terrace alluvial surface at 22 to 26 ft on the west side of the river and at 30 ft on the east side. At Hockanum (East Hartford) a riser separates the alluvial floodplain, which is at an elevation of about 19 ft, from the terrace alluvial floodplain at an elevation of 33 ft. A similar riser is shown in figure 3 at Keeney Cove. Risers are present along the east side of the Connecticut River in the northeastern corner of the quadrangle and along the western side of the river north of Wethersfield Cove. Between Wethersfield Cove and South Wethersfield a gentle slope, rather than an abrupt one, separates the two plains. In the southern part of the quadrangle the Connecticut River is restricted between high banks that confine the floodplain to a narrow strip or eliminate it completely. The alluvium is as much as 40 ft thick in the northeastern part of the quadrangle. The alluvium wedges out at the sides of the floodplain.

Figure 3 shows that the glaciolacustrine sand and some of the varved clay have been removed by the meandering of the Connecticut River within its floodplain.

The Connecticut River alluvium is mainly gray, fine- to medium-grained sand with some silt, clay, and a little gravel. The sediments contain organic matter, including bits of wood and clam and snail shells.

SLIDEROCK

Loose, angular blocks of rock have accumulated at the base of some steep cliffs and lie on bedrock slopes. These deposits are most widespread at the base of Cedar Mountain, whereas smaller accumulations lie on the slopes of Vexation Hill and at the bases of ridges in the southeastern part of the quadrangle.

Most of the sliderock fragments are of basalt. However, on the ridge that crosses the Berlin-Rocky Hill Town Line and on the east side of Vexation Hill, the fragments are largely of arkose. The blocks vary in diameter from 1 to 2 in. to about 5 ft; in general, the larger size is more conspicuous. Their shape is largely dependent on fracturing in the source rock, and on bedding planes in the sedimentary rock. The deposits are generally thin on the slopes but may be several tens of feet thick at the base of the cliffs.

The accumulations are mainly the result of rocks sliding or falling down cliffs in response to gravity. The blocks become loosened largely by frost or root wedging. In addition to coarse rock fragments, the deposits contain smaller particles which have been washed or blown in. At the cliff base sliderock overlies till or glaciofluvial sediments of kame terraces.

SWAMP DEPOSITS

Within the quadrangle numerous swamps occupy shallow depressions where drainage has been impeded by relatively impermeable material, by a high water table, or by both of these conditions. Several swamps on the uplands are underlain by clayey till through which water cannot flow freely. Such swamps tend to be the sources of streams; as examples, Goff Brook and Two Stone Brook, both in Wethersfield, may be cited. Examples of swamps in stream valleys, where the water table is generally high and usually at the surface in wet weather, are those near the headwaters of Folly Brook, Mill Brook, and Webster Brook—all in Newington—and those along the Mattabesset River in Berlin. In many instances, these stream-valley swamps are underlain by varved clays which also impede drainage.

In general, a stream originating in and flowing through till areas has a swamp as its source and few or no swamps along its course, whereas a stream in glaciofluvial sand and gravel generally flows into a swamp and has swamps along its course.

In addition, both the floodplain and the terrace alluvial plain of the Connecticut River are the sites of swamps. In the depressions (in some instances man made) on the terrace alluvium plain there are generally sluggish streams as well as swamps. On the floodplain the swamps generally occupy depressions resulting from the meandering of the river across its valley. The largest swamp in the quadrangle is on the floodplain of the Connecticut River at South Wethersfield. Small arcuate swamps fill depressions associated with point bars. Some of these are shown east of the junction of Highways I-91 and State Highway 3; many others are present but too small to map.

There are a few small, shallow swamps on the glaciofluvial plain near the Hartford-Middlesex County Line in Cromwell. The flatness of this area and the fairly high water table there may account for their presence.

Some of the swamps are open; others show forest encroachment around their peripheries; a few are completely forested. The swamp material beneath the living cover of woody and herbaceous plants is black to dark-brown peaty material consisting of a mixture of decayed vegetation, sand, silt, and clay. These deposits vary in thickness from a foot or two in the smaller swamps to as much as 23 ft in the large swamp east of the Wilbur Cross Highway and south of Wells Road in Wethersfield (Philip Keene, Connecticut State Highway Department, personal communication). In most places the swamps are directly underlain by fine sand, silt, and clay.

WIND-BLOWN DEPOSITS

Wind-transported sand forms dunes on the terrace alluvium plain east of the Connecticut River in the northeastern part of the quadrangle. The dunes rise to as much as 18 ft above the general level of the plain. Some are distinct ridges, oriented in a general north-south direction; others are irregular knolls with no preferred trend. Old Hockanum Cemetery is located on one of these irregular dunes (pl. 1). Other dunes are found east of Piper Brook in the vicinity of the junction of the Hartford, West Hartford, and Newington Town Lines. These are irregular in shape and rise only about 10 ft above the general level of the bottom plain of former Lake Hitchcock. The material in the dunes is a well sorted and stratified, medium- to fine-grained, yellow-brown to brown sand.

A thin, discontinuous veneer of yellowish-brown fine sand and silt is present over much of the quadrangle, but is too thin and patchy to be mapped. Its maximum observed thickness, excluding the dunes, is about 2 ft. This wind-deposited sediment overlies till, glaciofluvial deposits, and glaciolacustrine deposits, and is difficult to distinguish from underlying water-laid material of similar texture.

Although there are no dunes on the present floodplain of the Connecticut River, they are found on a former floodplain (the terrace alluvium) and on the bed of former Lake Hitchcock. The absence of dunes on the present floodplain may indicate that they formed prior to the construction of the floodplain, but it is also possible that the frequent flooding of the river may obliterate incipient dunes as they form. In any event, dune formation followed the construction of the earlier floodplain. The sources of the dune sand and other wind-deposited sediments are probably the exposed bed of Lake Hitchcock and the floodplains of the larger streams. The presence of dunes on only the east sides of the Connecticut River and Piper Brook suggests that the effective winds were from the north and west.

ARTIFICIAL FILL

Artificial fill, deposits made by human activity, consists of large accumulations of trash as well as railroad, highway, and building-construction fills. All types of sediments are used for fill, but glaciofluvial sand and gravel make up the bulk of it. Because the Hartford South quadrangle is intensively settled and highly industrialized, with numerous highways traversing it, fill is the surficial material in many localities. In the densely populated areas it is difficult to determine whether the surface material is natural or artificial; buildings, streets, driveways, lawns, and water and sewer lines prevent its study.

Fill less than 5 ft thick and too small in extent to show at true scale is not mapped on plate 1. The problem of mapping natural deposits is complicated by the fact that large areas have been stripped of surficial material to supply fill or levelled for industrial and urban development. For instance, in the area adjacent to the Wilbur Cross Highway very little of the natural surface remains.

In the past, most artificial fill was obtained from areas adjacent to the site where it was needed. Today, large construction projects require that fill be transported from greater distances. For example, the fill for Highway I-91 in Wethersfield was obtained largely from the Dividend Pond area in Rocky Hill.

GLACIAL AND POSTGLACIAL HISTORY

The landscape of the Hartford South quadrangle is largely the result of faulting, weathering, and stream erosion during the long time prior to the Pleistocene Epoch. Glacial erosion modified this landscape to some extent, but there is little doubt that the main features of the bedrock topography are preglacial in origin. The Connecticut River was the principal drainage channel before the Ice Age, and the trap ridges controlled the tributary-stream distribution much as in the present drainage system. During glaciation the ice removed the preglacial residual soil and replaced it with a veneer of drift, substituted a rolling glacial topography for the pre-existing one, modified the drainage by the creation of small lakes and swamps, and slightly reduced relief by filling in the depressions, mainly with glaciofluvial and glaciolacustrine sediments.

In various places in North America there is evidence of major Pleistocene ice advances separated by long intervals during which the climate was as warm or warmer than that of today. No evidence of multiple glaciation has been found in the Hartford South quadrangle; all of the deposits are the result of the last, or Wisconsin, glacier. This mass of ice is believed to have advanced through the quadrangle in the general direction of S 12° W, as indicated by striations and drumlins, and to have reached as far south as Long Island, where it left end moraines along its front. At that time the ice must have been well over 1,000 ft thick in the Hartford area, since it covered the Hanging Hills (Meriden quadrangle, Hanshaw, 1962) and Lamentation, Beseck, and Higby Mountains in the Middletown quadrangle. Very little is known about the initial advance of the glacier and the nature of its front, but during deglaciation the lobate form of the ice margin in many parts of this continent is well documented by terminal moraines that mark the limits of minor readvances. No such moraine has been recognized in the Hartford area, but the position of the lobe and its readvance in the Connecticut Valley is marked by other means.

Because much of the record of deglaciation lies in the quadrangles surrounding Hartford South only brief mention of it will be made here. There was ice in the lowlands when the eastern highlands and the high trap ridges were emerging through the thinning ice cover. This is indicated by the high-level spillways—channels that carried the meltwaters away from the Connecticut River—and the glaciofluvial deposits associated with them. Such spillways are located in the Glastonbury quadrangle, in the New Britain quadrangle (Simpson, 1959) and in the Meriden quadrangle (Hanshaw, 1962).

The areas in the Hartford South and Middletown quadrangles where deposits of varved clay occur were free of ice at the time that the clay was deposited. The presence of the clay also suggests that a dam existed across the Connecticut River below Middletown, causing ponding of the meltwaters in which these clays were laid down. It is presumed that at this time a tongue of ice occupied the Connecticut River valley north of Hartford and that blocks of ice filled or partly filled some bedrock depressions even as far south as Middletown (Flint, 1933).

The glacier subsequently readvanced over the lower varved clay, as indicated by numerous examples of deformed varves (fig. 11) and by the till containing fragments of varved clay which overlies the lower varved clay. The glacier probably readvanced as far south as Middletown (Flint, 1953, p. 899). There is no evidence to suggest that a long time intervened before this readvance; it is quite possible that only a minor fluctuation or series of fluctuations are represented by the readvance. A similar small fluctuation previous to the Middletown readvance may be indicated by the silty to clayey till in borehole SD-14 (table 2) at a depth of 32 to 36 ft which underlies the varved clay and overlies the basal till.

The filling with glaciofluvial sediments of the alternate course of the Connecticut River through the Jobs Pond area east of Portland (Middle Haddam quadrangle) may have taken place prior to or at the time of the Middletown readvance.

The resurgence of the glacier was followed by a period of ice stagnation accompanied by excessively rapid melting, as shown by the predominance of glaciofluvial deposits laid down at this time. The deposits of sand and gravel in the Wilbur Cross Highway area were formed toward the close of and following this readvance. These deposits are extremely complex in origin but have the characteristics throughout of ice-contact sediments associated with both active and stagnant ice. In the early stages of their deposition, the meltwaters that deposited the sand and gravel probably drained southward through the Silver Lake area in the Meriden quadrangle. This drainage channel is at about 165 ft altitude. When a lower outlet down the Mattabesset River was opened, the Silver Lake outlet was abandoned. Several other spillways (indicated by *M* on pl. 1) which were very short lived, drained meltwaters from the ice that occupied the valley of the Connecticut River north of Rocky Hill. The abandoned spillway southeast of Vexation Hill is at 193 ft and probably drained southwestward into the Quinnipiac River system in the Meriden quadrangle. The others, all in Rocky Hill, are located on Cromwell Avenue south of West Street (175 ft), on Cromwell Avenue

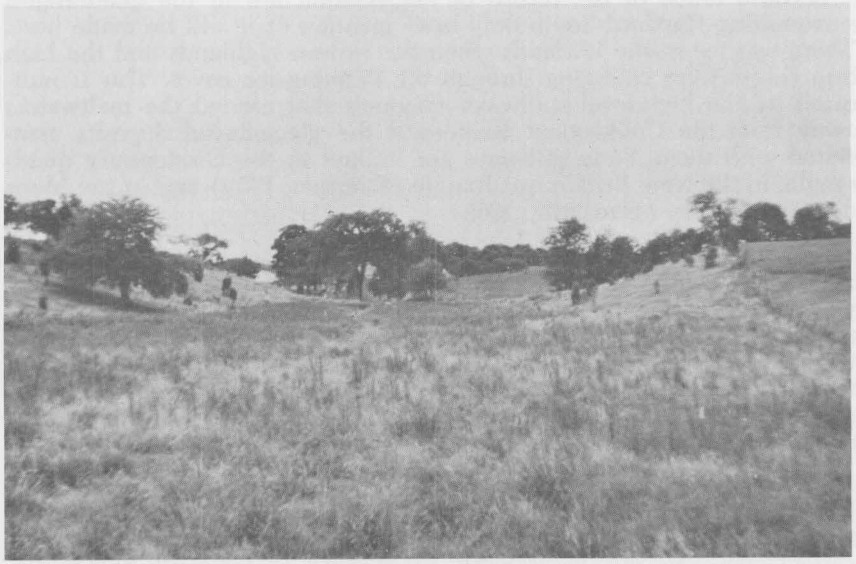

Fig. 16. A spillway, elevation 170 ft, that carried meltwaters from the ice north of the Rocky Hill anticline into the Mattabesset drainage system. Cromwell Avenue 500 ft north of West Street, Rocky Hill.

north of West Street (170 ft; fig. 16), and south of the State Veterans Home (165 ft). Drainage through these spillways was into the Connecticut River system, or through the Silver Lake area into the Quinnipiac River system.

The glaciofluvial sediments in the southeastern part of the quadrangle were deposited at the same time as or slightly later than was the sand and gravel in the Wilbur Cross Highway area. Varved clay underlies the sand and gravel in the southwestern corner of this outwash plain and it is presumed that, although parts of the Mattabesset River valley may have been occupied by a stagnant block of ice, the part in which the varved clay was deposited was ice free.

It is recognized that the Berlin Clay may have been deposited in an early phase of Lake Hitchcock, but in this report the term Lake Hitchcock is restricted to that lake phase (following the Middletown readvance) when the Hartford Clay was deposited. Lake Hitchcock is considered to have come into existence shortly after the resurgence of the ice to Middletown. The lake outlet then stood at slightly above 150 ft altitude and the dam consisted mainly of the outwash sand and gravel that filled the Connecticut River valley below Middletown. In this initial stage the lake was probably a narrow body of water marginal to the periphery of the Connecticut Valley ice lobe. The lake also completely submerged some of the isolated blocks of ice in the lowlands. It probably had many of the characteristics of a large river. It extended into the eastern part of the New Britain quadrangle, the northeastern corner

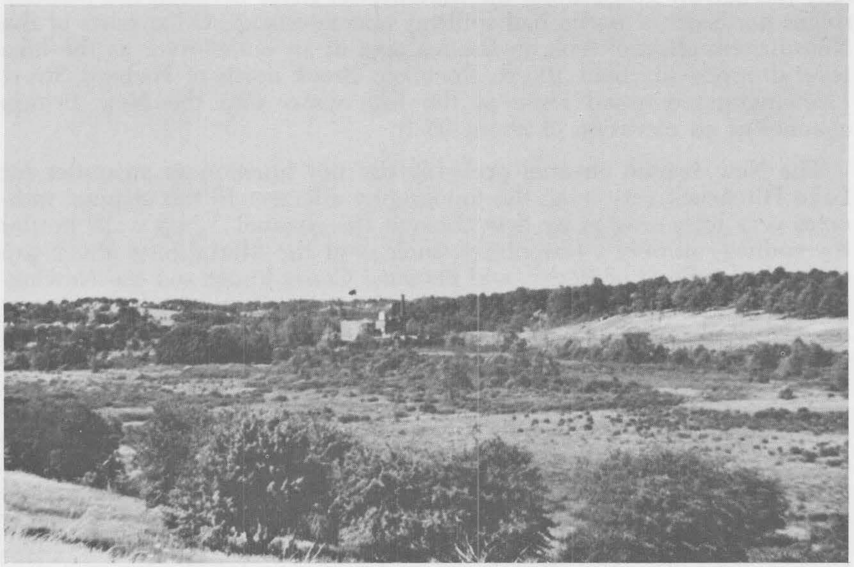

Fig. 17. The New Britain channel south of Highway 174, looking north.

of the Meriden quadrangle, much of the northern part of the Middletown quadrangle, and the western part of the Glastonbury quadrangle. The lake borders of this stage coincided roughly with the 150-ft contour in each of these quadrangles. The higher parts of the Hartford area projected above the water as islands.

The rapid rate of melting during the initial stages of Lake Hitchcock produced a high discharge down the Connecticut River. It is possible that the deposition of most of the coarse-grained streamload in the Hartford South and Glastonbury quadrangles produced a degrading stream below Middletown, with the result that the removal of valley fill and the lowering of the level of Lake Hitchcock was rapid.

The outlets of the lake within the Hartford South quadrangle are labeled *H* on plate 1. The erosion of the sand and gravel dam across the Connecticut River between Rocky Hill and the southeastern corner of the map probably kept pace with the downcutting below Middletown, so that this outlet, here called the Rocky Hill outlet, functioned throughout the life of the lake. A second outlet, known as the New Britain channel (Flint, 1933, p. 975), was in existence for a time in the western part of the quadrangle. The course of this spillway follows Piper Brook and the east branch of the Hartford, New Haven, and New York R. R. southwest of Elmwood into the New Britain quadrangle just north of New Britain Avenue (Newington), skirts the eastern edge of the New Britain area for about a mile (fig. 17), re-enters the Hartford South quadrangle along the course of Webster Brook, thence runs into the Mattabesset River, and finally into the Connecticut River. During the early stages, when the level of the lake was well above 100 ft altitude, only the narrow gorge along the Mattabesset River between the bedrock ridges northeast of Berlin had spillway characteristics. Other parts of the New Britain channel took on the features of an outlet river as the lake level dropped to about 100 ft. Rockhole Brook north of Richard Street (Newington) emptied some of the lake water into the New Britain channel at an elevation of about 95 ft.

The New Britain channel probably did not function as an outlet for Lake Hitchcock very long; the topography adjacent to the channel indicates very little erosion by flow through the channel. Steep walls border the spillway in only a few places, such as at the Mattabesset River gap one mile northeast of Berlin, and between Cedar Street and the Newington-Berlin Town Line. In places the outlet is floored with swamp deposits; at the divide, which is at an elevation of 73 ft, 2 to 3 ft of gravel overlie Triassic shale. The coarse-grained fraction of drift and the bedrock removed by downcutting of the channel in the Newington section were carried to the lowland area in the southwestern corner of the Hartford South quadrangle and the southeastern corner of the New Britain quadrangle and there deposited as an alluvial fan or delta. Some of the fine fraction was carried down the Mattabesset River. A radiocarbon date from wood fragments collected from the delta gravel indicates that the downcutting was in progress about 10,700 years ago (Flint, 1956, p. 276). The New Britain channel was abandoned when the dam of outwash sand and gravel in the Connecticut River below Middletown was eroded to below about 73 ft. The cause of the abandonment was the fact that the silt, sand, and gravel in the Rocky Hill outlet was more easily erodible than the bedrock floor of the New Britain channel.

As the ice front melted and retreated northward in the Connecticut River valley, Lake Hitchcock expanded; it remained at the 150-ft level for a short time only. Shore bluffs were not developed in the Hartford South quadrangle, although they are recognized in the Hartford North quadrangle (Cushman, 1963). The upper limits of Lake Hitchcock in the Hartford South area, however, are clearly defined by the beach gravels. Varved clay was deposited in the deepest parts of the lake, and furnishes a minimum altitude for the lake. As the dam holding Lake Hitchcock was eroded, the level of the lake dropped, and the water was confined between ever-narrowing shores.

Lake Hitchcock may be considered to have become extinct when the level dropped to about the present 45-ft elevation in Wethersfield. At this level the lake became so confined that it took on the characteristics of a river and started to degrade its bed. With continued erosion of the dam and subsequent rise of sea level, the floodplain became narrower, as it is today.

Postglacial changes in the quadrangle include the development of the various soil types, the accumulation of sliderock at the base of the steep bedrock ridges, the deposition of a thin veneer of wind-blown sand and silt over some parts of the area, the accumulation of peat in the swamps, and the growth of forests over the land. The recent changes made by man, however, have almost completely obliterated the record of the Pleistocene sequence described above. Unless efforts are made in the very near future to preserve some of the glacial features, the record will exist only in the files of the State Geological and Natural History Survey.

ECONOMIC GEOLOGY

Sand and gravel

The only economically important deposits of sand and gravel are glaciofluvial sediments. The area along the Wilbur Cross Highway between Berlin and Robbins Avenue in Newington has supplied most of the commercial sand and gravel from deposits that varied in thickness from a few feet to as much as 60 ft. The usable material was mainly confined to hills and ridges. This area, however, has now ceased to furnish much material, not only because the supplies have been nearly exhausted, but also because urban and industrial developments cover much of the land there.

A second important sand and gravel area lies south of Hog Brook (Rocky Hill) and east of Silas Deane Highway. Some pits here have been excavated to a depth of 90 ft.

In both of these areas the value of the deposits for use in concrete aggregate is diminished by the high iron content which gives the material a pink to red color. In addition, many of the coarser particles are coated with silt and clay. Although washing can increase the value of the sediment, it is impossible to remove all of the iron oxide; in addition, many of the sand-size fragments are of red shale or arkose.

In most deposits, the upper part is medium to coarse gravel and coarse sand, overlying and grading into medium to fine sand. In places the gravel is dirty, resembling a gravelly till. Locally the sand and gravel has been cemented to form a conglomerate. The principal use of the sediment has been as fill.

The glaciofluvial plain in the southeastern part of the quadrangle is composed of a much more uniform grade of material than that of the deposits described above. Better sorted, it ranges from medium-grained sand to fine gravel, is cleaner than the ice-contact sediments, contains less till, and has less variation in grain size. The thickness, although unknown, is thought to be quite variable. In the single large pit south of Brook Street in Cromwell the water table stands about 15 ft below the surface. This sediment, although predominantly sand, is suitable for use in concrete aggregate, but its exploitation has been restricted because of the high value of this area as a nursery site.

Recently, the fine-grained sand and silt in the floodplain of the Connecticut River has been used as highway fill. The fineness of the sediment and its high organic content make it unsuitable for use in concrete aggregate; its value, however, will increase as the availability of other deposits decreases.

Silt and clay

Although varved clay has been used for brick making, there are no active pits within the quadrangle. Abandoned pits are found in the Berlin area (southwestern corner of the quadrangle) and at Elmwood in West Hartford. Some small areas of clay are still available, but the rapid expansion of industrial and residential areas is gradually making them inaccessible. The most extensive clay deposits are beneath the Connecticut River floodplain in the northeastern corner of the quadrangle. However, the high water table here would introduce water-pumping problems.

Both the Berlin Clay in the southwestern corner of the quadrangle and the Hartford Clay are satisfactory for brick making. The former shrinks less during firing, but the deposits in the northern part of the area generally contain too much silt and in some places this clay cannot be used for brick making because stones and concretions are so numerous.

Fill

The suitability of the quadrangle's various glacial deposits for use as fill depends on a number of factors. Not the least of these is demand, but ease of excavation, internal drainage, susceptibility to compression and expansion, and slope stability also are influential. Although water-laid sediments are the most easily excavated, lake-bottom and floodplain deposits are usually associated with a high water table. The glaciofluvial deposits have the best internal drainage. Ice-laid deposits are usually highly compactable and hence can be made impermeable; they also possess high slope stability. The tills derived from varved clays are least desirable as fill.

Swamp deposits

Small areas of swamp deposits lie along the west side of Wethersfield Township. They can be used as a soil conditioner, and the areas which they underlie are suitable for truck farming if properly drained.

Ground water

The most important water-bearing deposits of the quadrangle are the glaciolacustrine sands, terrace alluvium, and the alluvium of the Connecticut River floodplain. Although the aquifers are thin, seldom exceeding 35 ft, their yield in shallow wells is relatively high because of their great lateral extent and high permeability and because they are generally underlain by varved clay which is relatively impermeable and thus limits the vertical movement of the ground water.

Locally, glaciofluvial deposits may also be important (Cushman, 1964). The outwash plain in the southeastern part of the quadrangle is potentially a better source of water than the deposits in the Wilbur Cross Highway area because they are more uniform in texture and have a flatter surface. Test drilling would be necessary to determine the best water-yielding locations because the glaciofluvial deposits are highly variable in thickness and texture.

The varved clays and the tills derived from them are relatively impermeable and hence will not yield sufficient water for wells. The sandy tills are poor aquifers although locally they have provided a limited domestic supply in individual wells.

Depressions in the bedrock surface are likely areas for ground water (see figs. 3, 4). Bodies of sand and gravel in them, even if discontinuous, can yield good quantities of water if not sealed from recharging by overlying impervious layers of varved clay or clay-rich till. Systematic test drilling would be required to locate such water-bearing horizons.

Further information on the water-bearing possibilities of the sediments and rocks in the quadrangle is given by Cushman (1960, 1964) and by Cushman, Tanski, and Thomas (1964).

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