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A study of the physical properties of eolian influenced soils in the central lowland of Connecticut and Massachusetts.

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A STUDY OF THE PHYSICAL PROPERTIES OF EOLIAN INFLUENCED SOILS IN THE CENTRAL LOWLAND OF CONNECTICUT AND MASSACHUSETTS

RITCHIE, JR. · 1955

A STUDY OF THE PHYSICAL PROPERTIES OF EOLIAN INFLUENCED SOILS IN THE CENTRAL LOWLAND OF CONNECTICUT AND MASSACHUSETTS

by

Alexander Ritchie, Jr.

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INTRODUCTION

Much attention has been focused recently on the influence of eolian materials on soil profile characteristics in New England. This interest has resulted from emphasis placed on better soil utilization and management and new concepts in the classification and mapping of soils.

Relatively little detailed research has been devoted to the eolian influenced soils in New England. The need for more research on these soils was brought out in a discussion following the presentation of a paper by Colby, et al. entitled "The Influence of Windblown Material on the Soils of Massachusetts"[1] at the Northeastern Soil Research Committee meeting at Storrs, Connecticut, January 30, 1952. From the discussion it was agreed that more work on the nature and distribution of windblown materials was highly desirable and would add basic information to our knowledge of the soils of this area.

During soil survey operations in Hartford County, Connecticut extensive areas of loess derived soils have been mapped. Because of the agricultural importance of these soils, a cooperative research project between the Connecticut Agricultural Experiment Station and the Massachusetts Agricultural Experiment Station was started. This paper presents the results obtained from this research project.

The study was directed particularly toward gaining information on the characteristics of loess deposits in the Central Lowland of Connecticut

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[1] Colby, W. G., Pelissier, J., Epstein, E. and Bertinuson, T. The Influence of Windblown Material of the Soils of Massachusetts. Massachusetts Agr. Exp. Sta. (Mimeographed).

and Massachusetts as they influence soil profile characteristics. Emphasis was placed on the following loess characteristics: (1) area distribution; (2) depth; and (3) particle size distribution.

This study was devoted mainly to the Enfield soil series. This soil series was chosen for the following reasons: (1) the brownish colored silty veneer is easily observed since it makes a sharp contact with the underlying red colored glacial outwash and till deposits derived from Triassic sandstone and conglomerate; (2) the depth of the silty veneer represents the deepest layer observed in Connecticut and Massachusetts; (3) the area occupied by this soil series is rather extensive; and (4) this soil series is important agriculturally.

REVIEW OF LITERATURE

Origin and Deposition of Central Lowland Loess

Eolian activities associated with the Pleistocene ice sheets of North America are considered to be centered in the Mississippi Valley region of central United States. It is true that the most extensive areas and the most conspicuous deposits associated with eolian activities during the Pleistocene are found in this region, but the influence of eolian activities in other sections of the glaciated region of the United States can not be neglected. Loess has been reported as occurring farther east than the Mississippi Valley region, but it is patchy in its distribution and is relatively thin (9). It is locally recognizable as far east as the Boston region (24) and the Connecticut Valley (7).

Recent studies in Greenland and Alaska have brought out more clearly the role of eolian activity in regions glaciated during the Pleistocene. Observations by Hobbs (10) in the vicinity of the Greenland continental ice sheet indicate wind to be the dominant transportation agent within the extramarginal zones of the ice sheet.

A modern example of the deposition of loess comparable to that which took place during the retreat of the Pleistocene ice sheet has been described by Pewe (22) in the Tanana River Valley of Alaska. At present the Tanana River receives meltwater from many glaciers located about 30 to 50 miles upstream from its mouth, and consequently the river is heavily laden with silt. Where the river flows across the Tanana lowland, the gradient is relatively low; the floodplain here is one to two miles wide. There are intricately braided channels and numerous silt-covered bars that are characteristic of glacial drainage streams. Moderate to high intensity winds blowing from higher elevations sweep across these lowlands. When the silt is sufficiently dry it is borne in great quantities over the adjoining uplands.

Tuck (30) made a similar observation in the Matanuska Valley of Alaska. He describes a pall of dust as being visible over Palmer and the surrounding country in dry weather and even in the winter. Section corners staked in 1913 were found to be covered to a depth of several inches in 1935.

Loess is generally uncommon in moist regions, but is found in them. Loess of Wisconsin date occurs in New England in the Connecticut Valley lowland, close to a source of abundant outwash silt. This is in a region with an annual rainfall of 40 to 44 inches, well distributed throughout the year (9). According to Flint (9) loess is far more abundant in dry than in moist climates. He believes that "in general it is doubtful, that detailed climatic significance can be attached to loess as such, for the wind should be capable of deflating silt and clay of outwash just as long as these masses of fine sediments were kept bare by the rapidly shifting upbuilding streams".

Emerson (6) was probably one of the first geologists to recognize wind-blown material in the Connecticut Valley lowland. He described a layer of fine unstratified loess along the west slope of Amherst ridge presumably blown from the broad glacial lake bottom to the west.

A thin veneer of silty material has been recognized by Flint (7) which covers parts of the terraces that occupy the eastern flank of the Connecticut Valley lowland in the Hartford-Thompsonville section of Connecticut. The restriction of this deposit chiefly to the eastern side of the valley, its uniform nature and lack of stratification indicate a probable eolian origin.

The existence of loess on the east side of the Connecticut Valley has also been reported by Jahns (12). He has observed this material to blanket bedrock, till and outwash. The presence of ventifacts has been reported as further evidence of wind action.

In the following section, a review of literature pertaining to soil characteristics related to loess in the Central Lowland is presented. The view presented will illustrate the importance placed by soil scientists on loess as a parent material on soil development and management.

Soil Characteristics Related to Loess in the Central Lowland

Colby, et al. (4) believe that wind-blown material provides most of the moisture and nutrient holding capacity in many of the best soils of Massachusetts exclusive of organic matter. They believe that once this surficial mantle is lost under poor management practices, the agricultural value of the land is lost.

High amounts of silt in the profiles of many soils in the Central Lowland are thought to be due to eolian action (27). It is believed the unusually high silt content of the A and B horizons of the Merrimac and Wethersfield profiles reflect eolian origin.

In the vicinity of the Central Lowland most soils formed on glacial till cannot be considered as monogenetic profiles in the sense that the underlying till has contributed all of the solum material (1). Either fresh water and/or eolian sediments have been incorporated with the underlying weathered till.

Tamura and Swanson (29) have concluded that future studies on clay mineral transformation and soil genesis must be cautiously viewed; and the data must be carefully considered for evidence of eolian or foreign deposits.

The soils of the Enfield series were recognized very early in the soil classification scheme. The importance of this soil series was recognized when more detailed classification became possible. The following sections are intended to give the development of this important soil series with changing classification concepts.

History of the Enfield Series

The Enfield series was first established during the soil survey of the Connecticut Valley in 1899 (31). At this time, this series covered all soils having developed on a thin layer of sandy materials which overlay sandy and somewhat stony glacial drift. The underlying material was about two to three feet below the surface.

In 1928, the series name was applied to soils in the Connecticut Valley Lowland of Massachusetts with a narrower range of soil characteristics (15). The series at this time was restricted to soils having a texture ranging from a fine sandy loam to a loamy sand. The range in depth was from 20 to 36 inches at which depth the overlying sand rests on a red sandy clay glacial till or glacial terrace material derived from Triassic sandstone. This series was mapped in scattered areas throughout the Valley region.

Morgan in 1930 (20) made a further refinement of the Enfield series in the Central Lowland of Connecticut. He limited the series to soils with a very fine sandy loam and fine sandy loam texture. The profiles were developed on a layer of very fine sand and silt two to five feet in depth, overlying an older surface of either compact glacial till or water deposited sand and gravel. The surface soil color was described as being light brown, and the subsoil a grayish yellow color. Generally there was a complete absence of stone, gravel and coarse sand in both the surface and subsoil; though the underlying material may be quite stony or gravelly. The material forming this soil is believed to have been deposited by wind at the close of the ice age.

The description of the Enfield series used in the soil survey of the Scantic River watershed in Connecticut and Massachusetts (19) was similar to that used by Morgan. The Enfield was described as being developed from old wind and water deposits of finely divided crystalline fragments deposited over previously deposited stratified and unstratified glacial drift. The texture ranged from a very fine sandy loam to a sandy loam. During this survey the deep and shallow phases of Enfield were established. The deep phase ranged from 42 to 60 inches to the underlying material, and the shallow phase ranged from 20 to 30 inches to the underlying material. The shallow phase was usually found further east than the deep soil or on the top of hills and ridges.

In 1946, a few minor changes were made by the U.S.D.A., Division of Soil Survey (32). The Enfield soils were considered well drained Brown Podzolic soils, developed from fine or very fine sand deposits apparently of eolian origin. In most areas they overlie till but in some places may overlie glaciofluvial material. Inasmuch as these deposits occur dominantly in the eastern part of the valley, it appears they were blown by prevailing westerly winds and deposited over till and outwash. The depth to the underlying material ranges from 12 inches to several feet. If the deposit is less than 8 or 10 inches thick the soil is correlated as if it had developed on the unmodified underlying materials.

Present Concept of the Enfield Series

The present concept of the Enfield series (figures 1 and 2) was developed during the soil survey of Hartford County, Connecticut (5). This series at present includes well drained Brown Podzolic soils developed mainly from silts and very fine sand probably of eolian origin, overlying stratified sand and gravel or light textured till,

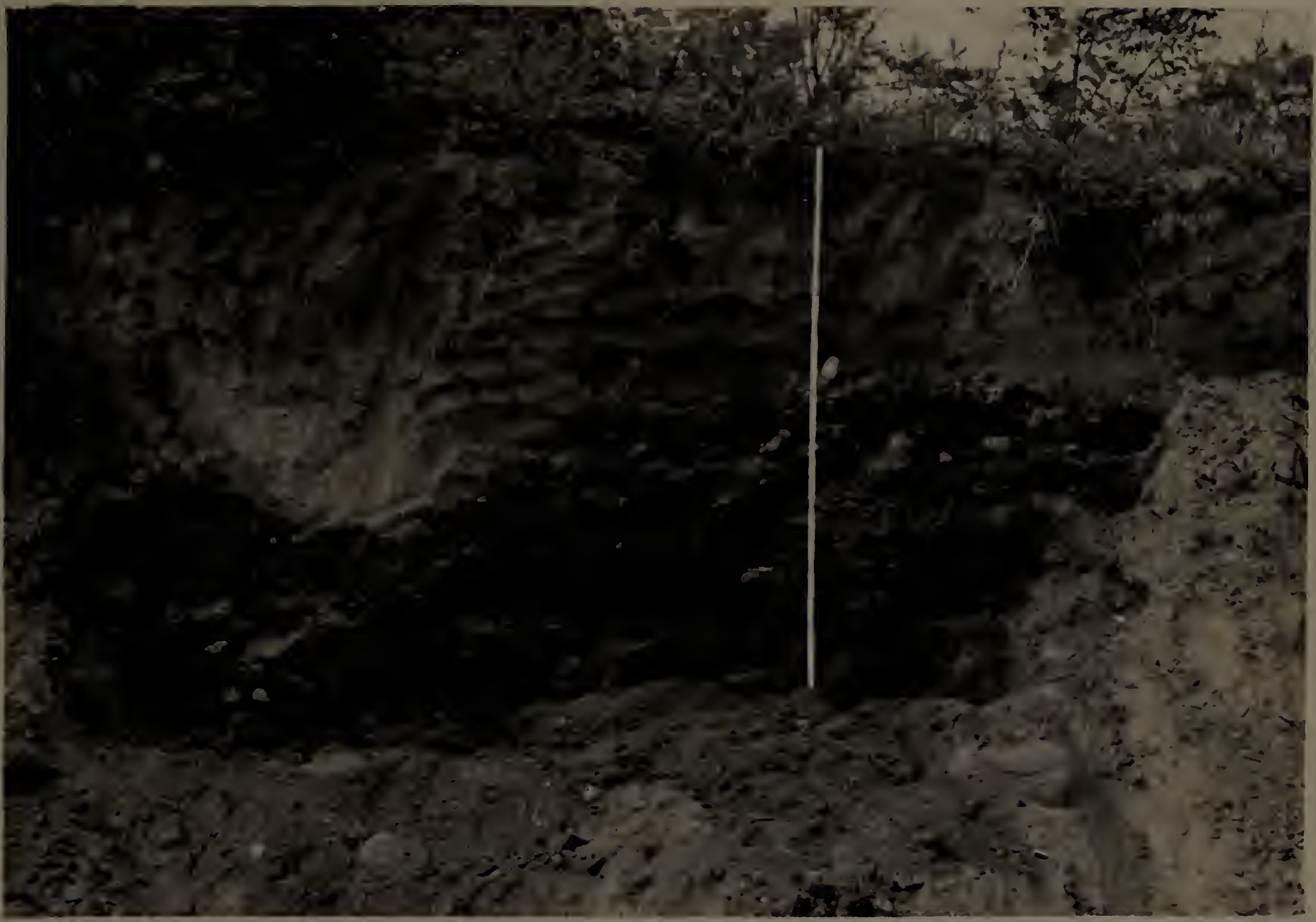

Figure 1. View of a profile of Enfield silt loam over glacial outwash sand and gravel. Photo taken on August 6, 1953 near Windsorville, Connecticut in gravel pit across the road from St. Catherine cemetery.

Figure 2. Profile of Enfield silt loam (over till). Note gravel in the B_{21} horizon. The till loess-till contact is at 24 inches. Location 0.6 mile north of the village of Buckland, Connecticut. Photo taken August 2, 1951.

which are derived mainly from sandstone and conglomerate of Triassic origin. The Enfield soils occur on both glaciofluvial or glaciolacustrine terraces and glaciated upland. At present the soils on till are being separated from those over sand and gravel on the basis of differences in the underlying material, topography and stoniness. Areas over sand and gravel are generally free of stone, whereas those over till are generally stony or very stony except where the stones have been removed by man.

The depth of the solum of the deep phase is variable and ranges from 18 to 30 inches but may be as much as 36 inches in places. The surface texture is mainly a silt loam although in places the texture is near a very fine sandy loam. The color of the B horizon varies from reddish yellow (7.5 YR 6/6) to yellowish brown (10 YR 4/4)[1/].

The shallow phase of the Enfield is characterized by a thin solum, ranging from 6 to 18 inches in thickness. Rounded gravel and angular rock fragments are generally present in moderate quantities on the surface and throughout the shallow solum.

Soils Associated With the Enfield Series

The moderately well drained Enfield is not at present an established series but it has been distinguished in the Hartford County soil survey (5). Mottling is present in the lower B horizon of the moderately well drained Enfield but is generally absent in the well drained Enfield except at the contact with the underlying till.

The poorly drained Enfield is included with the Walpole series.

This series includes poorly drained soils associated with the deep sandy soils.

The Broadbrook series includes well drained soils and differs from the Enfield series only in that it is underlain by a compact glacial till derived mainly from shale and sandstone of Triassic origin. The compact till tends to inhibit internal drainage.

The Poquonock series includes well drained soils developed from sandy glacial fluvial or eolian deposits on firm to very firm or compact glacial till. The surface texture is more sandy than that of the Enfield series. It ranges from a loamy sand to a fine sandy loam.

A more detailed description of the preceding series is given in the "Descriptive Soils Legend for Hartford County, Connecticut" (5).

EXPERIMENTAL PROCEDURE

Field Methods

Soil survey maps

Soil survey field sheets were available for all of Hartford County, Connecticut east of the Connecticut River where the largest areas influenced by loess are located. The base maps used in the survey were aerial photographs with a scale of 4 inches to the mile. These maps were invaluable since the distribution and depth of the deposits could be obtained from them and were freely consulted during this study. Soil survey maps are also available for some areas in Tolland County, Connecticut also on the east side of the Valley.

Inspection trips

Field inspection trips were made to study loess depth, topographic distribution and other related features in areas not covered by soil survey maps. Pits large enough to observe profiles were dug in areas where fresh road cuts were not available.

Sampling procedure

Soil samples for laboratory determinations were collected according to a predetermined systematic method in order to avoid bias. The method of sampling adopted consists of a series type method established on a grid as proposed by Krumbein and Pettijohn (14). A grid was laid out in one square mile blocks covering an area three miles by four miles on a map covering an area strongly influenced by loess (figure 3). One sample site per square mile was selected.

The recording of the samples was greatly facilitated by the adoption of a numbering and lettering system by which each sample is identified by a code number and letter. Numbering was begun on the northernmost tier of the grid with row number "1". Letters were used beginning with the letter "A" at the western end of the grid.

Changes in the loess mantle brought about by weathering processes following the period of its deposition might easily obscure any differences in the mantle deposited at different locations (23). To hold the effects of weathering to a minimum, C horizon samples were obtained wherever possible. The sample sites were restricted to comparable topographic positions wherever possible. The slope was restricted to nearly level to very gently sloping topography

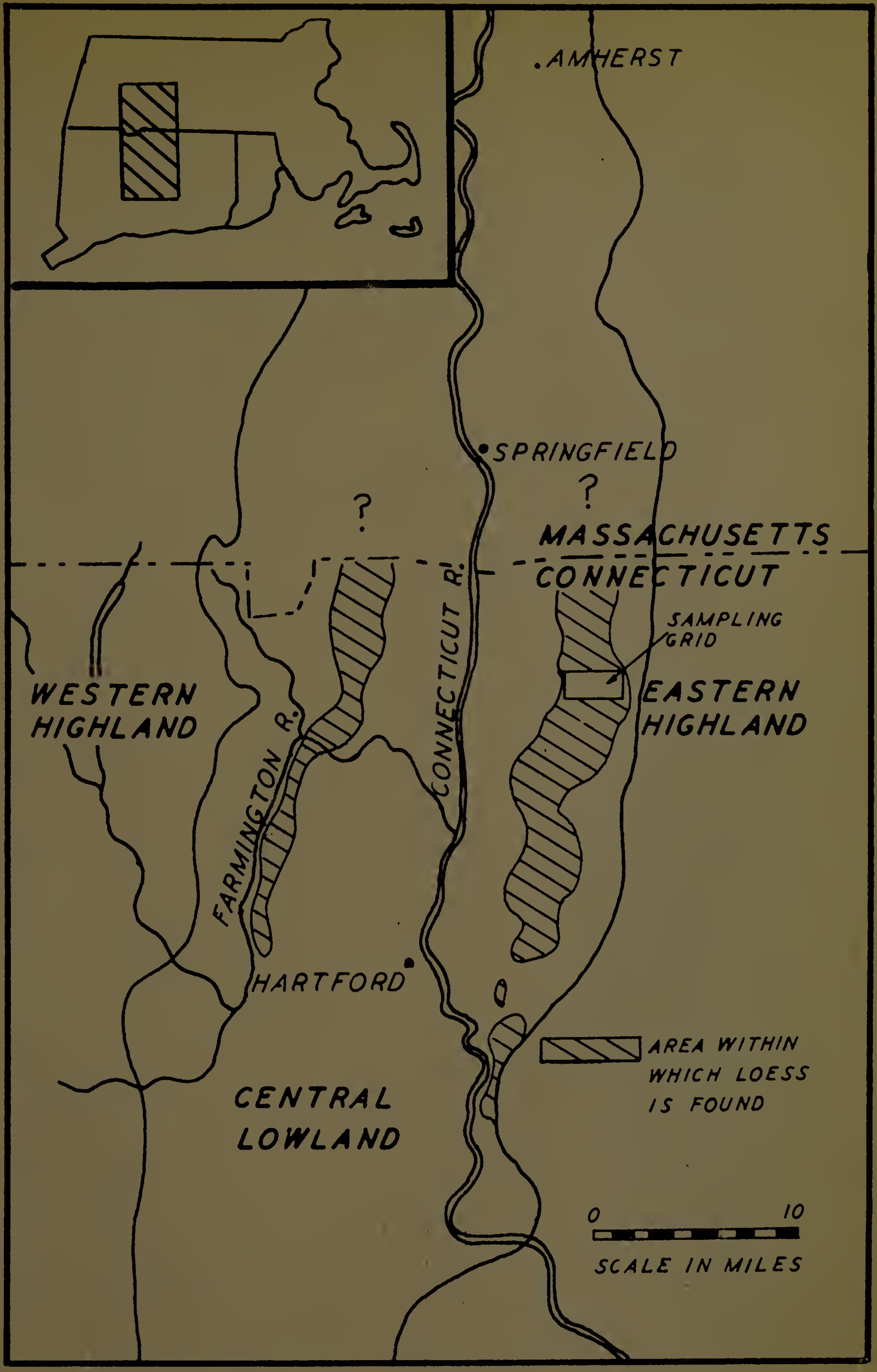

Figure 3. Location map of loess distribution and sample area.

which seldom exceeded three to four per cent. Each sampling site occupied a well drained position. All of the samples were obtained from undisturbed profiles under forest vegetation.

A sampling pit approximately six feet long, three feet wide and three feet deep was dug at each site. Detailed descriptions of the profile and area were made. Each end of the pit was sampled by horizons; a bulk sample representative of each horizon was obtained. Undisturbed core samples were obtained by using the Swanson portable soil core sampler (26).

Laboratory Methods

The bulk samples were spread out and air dried on clean brown wrapping paper in the laboratory. The aggregates and lumps were crushed with a rolling pin. The gravel particles greater than 2 mm were screened out and the weight recorded. The samples were well mixed and stored in quart ice cream containers until ready for analysis.

The mechanical composition of the samples was determined by the pipette method of Kilmer and Alexander (13). The fundamental principle of the pipette method is based on Stokes law. This method is used to determine the particle size distribution in a suspension at a given depth as a function of time. Variations in particle size distribution are measured by taking out samples of a definite volume, at a given time, at a given depth and drawn at a definite rate. The mineral matter is determined by drying the aliquot at 105°C. and correcting for the added dispersing agent. Previous to pipetting the samples are treated with hydrogen peroxide to remove organic matter, filtered by the use of Pasteur-Chamberlain filters to remove soluble salts and dispersed with sodium hexametaphosphate.

One change in the procedure was the substitution of aluminum pans for platinum dishes during the final drying of the sand separates. Some difficulty was encountered in the removal of organic matter in the A horizon samples by the hydrogen peroxide method prescribed.

Permeability, penetrability, soil porosity, bulk density and field moisture were determined by the methods described by Bourbeau and Swanson (1). The pH measurements were made potentiometrically, using the glass electrode in a 1:1 soil-water mixture as described by Peech, et al. (21).

RESULTS

This section includes data obtained from field observations and measurements, mechanical analysis and core studies. The measurements obtained from soil cores include field moisture, bulk density, pore volume, permeability and penetration.

Area Distribution of Loess

Loess has been observed to cover parts of terraces, till and bedrock on the east side of the Central Lowland of Connecticut and Massachusetts as far south as Portland, Connecticut and as far north as Amherst, Massachusetts. Loess has been reported by Jahns (12) to be common in the vicinity of Amherst and in the rolling country north and northwest of Cushman. The largest areas influenced by loess in Connecticut are located in the towns of East Hartford, Manchester, South Windsor, Enfield and Ellington. The loess, however, does not form a continuous mantle over the area indicated on the map, though non-delineation does not necessarily rule out its presence (figure 3).

Another area of loess has been observed on the west side of the Central Lowland. The loess in this area blankets portions of Talcott Mountain (a trap rock ridge) east of the Farmington River (figure 3). The outwash plain adjacent to the river was probably the source area for this deposit.

Physiographic Location of Loess

The loess occurs as a surficial mantle which conforms closely to the general contour of the buried pre-loess topography, filling up the depressions in the old surface. The deposits are thicker on the leeward side of slopes and in the depressions. It is generally thin or absent on till tops. The most continuous and deepest deposits are found on broad smooth uplands and wide flat terraces. It is assumed that the deposit may have been removed by erosion in areas under present or previous cultivation where the deposit is absent or very thin. The mantle distribution is independent of elevation, and ranges from about 150 feet to 450 feet above sea level in the area where the research samples were collected.

Ordinarily the loess rests with a sharp, well defined contact on the underlying deposit with little indication of weathering below the contact (figure 4). According to Flint (7) this sharp contact

Figure 4. Close-up of Enfield silt loam (over outwash sand and gravel) in figure 1. Note the sharp contact between the underlying stratified outwash materials and the overlying profile developed in loess. An old plow layer (A_p) is present in the upper 6 inches of loess. The remainder (6-24 inches) of the profile constitutes the B horizon and the underlying stratified sand and gravel the D horizon. No C horizon is present in this profile. Photo taken August 6, 1953.

on the underlying deposit with little indication of weathering below the contact (figure 4). According to Flint (7) this sharp contact suggests that the loess was deposited during the later stages of deglaciation when the terraces were drained but not covered with vegetation. The unweathered loess lacks any noticeable stratification.

Depth of Loess

In thickness, the mantle varies from a few inches to several feet. The mantle has been observed to be as deep as five feet; but this is the exception rather than the rule. The deeper accumulations are found on the leeward side of hills and depressions. Mantle depths of three feet and less are generally the normal depth for the area studied.

There is a definite trend for the mantle to become thinner with progressive distance from the source area. At a distance of three miles the mantle is very thin or absent, and beyond this it is almost impossible to recognize any evidence of a mantle.

DESCRIPTION OF THE ENFIELD SILT LOAM PROFILES STUDIED

Profile 1A

Location:	Town of Enfield; one and one-quarter miles N of the village of Melrose on State Highway 119 on the E side of the road. Coordinates on soil profile location map (Broadbrook USGS[1] quadrangle): No. 5; 4.0-F.1[2];653. Sampled 4/14/54.
Topography:	Sampled near top of drumlin on 5% W slope. Elevation 180 feet above sea level.
Vegetation:	Red maple (Acer rubrum L.) and scattered eastern hemlock (Tsuga canadensis L.).
Parent Material:	Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar, probably derived from granite, gneiss, and schist. The eolian material rests with a sharp contact on stratified sand and gravel derived mainly from sandstone and silt stone of Triassic origin.
Sampled by:	A. Ritchie, Jr. and D. B. Downs.

Horizon	Depth	Description
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1 1/2"	Organic debris partially decomposed.
A_1	1 1/2-4"	Dark brown (7.5 YR 3/2)[3] silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	4-12"	Brown (7.5 YR 4/4) silt loam; friable; weak medium subangular blocky.
B_{22}	12-23"	Reddish brown (5 YR 4/4) very fine sandy loam; friable; single grain; lower boundary grades gradually into underlying horizon.
C_1	23-33"	Reddish brown (5 YR 4/3) very fine sandy loam; friable; single grain; few mottlings present; lower boundary is sharp.
D_1	33+"	Dark reddish brown (5 YR 3/4) glaciofluvial sand and gravel derived from sandstone and siltstone of Triassic origin.

Profile 1B

Location:	Town of Enfield; about 2.7 miles SE of village of Scitico near Enfield-Ellington town line. Coordinates on soil profile location map (Ellington USGS quadrangle): No. 1;4.3-A.3;6503. Sampled 11/25/52.
Topography:	Gently sloping till plain with a 2 to 3% slope to the W. Elevation 360 feet above sea level.
Vegetation:	Cut over forest; mainly young white oak (Quercus alba L.) with gray birch (Betula populifolia Marsh), red maple (Acer rubrum L.), aspen and wild black cherry (Prunus serotina Ehrh).
Parent material:	Silts and very fine sand of eolian origin composed chiefly of quartz, mica, and feldspar probably derived from granite, gneiss and schist. The eolian material rests with a sharp contact on glacial till.
Sampled by:	A. E. Shearin, H.A. Doehne, C.L.W.Swanson, D.B.Downs and A.Ritchie, Jr.

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[1] United States Geological Survey.

[2] Location maps on file in the Department of Soils, The Connecticut Agricultural Experiment Station, New Haven, Conn.

[3] Color determinations on moist soil.

Horizon	Depth	Description[4]
A_{00}	1-0"	Loose leaves and organic debris, largely undecomposed.
A_0	0-1/4"	Organic debris partially decomposed.
A_1	1/4-3"	Very dark grayish brown (10 YR 3/2) silt loam; very friable; fairly high in organic matter, well mottled with fine roots; lower boundary indistinct.
B_{21}	3-14"	Strong brown (7.5 YR 5/8) silt loam; very friable; very weak medium subangular blocky; fine roots fairly numerous, lower boundary indistinct.
B_{22}	14-22"	Strong brown (7.5 YR 5/8) to reddish yellow (7.5 YR 6/6) silt loam; very friable; very weak medium subangular blocky; roots less numerous than in overlying horizon; lower boundary sharp.
B_1	22+"	Yellowish red (5 YR 4/6) sandy loam to coarse loamy sand till with streaks or spots of very pale brown (10 YR 7/4) fine sandy loam. The till is derived mainly from Triassic conglomerate, sandstone, and arkose and is generally very firm in place but breaks down easily when disturbed. A few stone and angular rock fragments of sandstone, conglomerate, arkose, gneiss and quartz are scattered over the surface and throughout the profile.

Profile 1C

Location: Town of Somers; about 2.0 miles S of the village of Somerville on Somersville-Ellington road on E side of road. Coordinates on soil profile location map (Ellington USGS quadrangle): No. 2;4.3-B-3; 6503. Sampled 4/27/54.

Topography: Gently sloping till plain with a 3% slope to the W. Elevation 360 feet above sea level.

Vegetation: Cut over forest area; mainly white oak (Quercus alba L.) mixed with scarlet oak (Quercus coccinea Muenchh), black oak (Quercus velutina Lam.) and gray birch (Betula populifolia Marsh).

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss and schist. The eolian material rests with a sharp contact on red glacial till derived mainly from sandstone, conglomerate, and siltstone of Triassic origin.

Sampled by: A. Ritchie, Jr., C.L.W.Swanson, T. Tamura, R.M. Hanna.

Horizon	Depth	Description
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1"	Organic debris partially decomposed.
A_1	1-3"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	3-14"	Brown (7.5 YR 4/4) silt loam; friable; weak medium subangular blocky; lower boundary grades gradually into underlying horizon.

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[4] Profile description by A.E. Shearin 11/25/52.

Horizon	Depth	Description
B_{22}	14-24"	Strong brown (7.5 YR 5/6) silt loam; friable; very weak medium subangular blocky.
C_1	24-36"	Gray brown (10 YR 5/2) sploched with yellowish brown (10 YR 5/6) silt loam; friable; single grained; boundary to underlying horizon abrupt. This horizon is very irregular in thickness in places it is absent.
D_1	36+"	Reddish brown (5 YR 4/4) and dark reddish brown (5 YR 3/3) fine sandy loam; very firm; single grained; glacial till. The till is derived mainly from conglomerate, sandstone and siltstone of Triassic origin. Some stones and angular rock fragments are scattered throughout the profile.

Profile 2A

Location: Town of Ellington; on dirt road one mile NE of the village of Melrose near Enfield town line on the W side of the road.

Topography: Gently undulating kame terrace. Elevation 240 feet above sea level.

Vegetation: Cut over forest; mainly white oak (Quercus alba L.) with an understory of white pine (Pinus Strobus L.).

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss, and schist. The eolian material rests with a sharp contact on stratified gravel and sand.

Sampled by: A. Ritchie, Jr. and D.B. Downs.

Horizon	Depth	Description
		Granular more type[5]
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-3/4"	Organic debris partially decomposed.
A_1	3/4-5"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	5-15"	Strong brown (7.5 YR 5/6) silt loam; friable; weak medium subangular blocky, roots numerous; lower boundary grades gradually into underlying horizon.
B_{22}	15-24"	Strong brown (7.5 YR 5/6) to brown (7.5 YR 5/4) silt loam; friable; very weak subangular blocky; boundary grades gradually into underlying horizon; roots numerous.
C_1	24-40"	Brown (7.5 YR 4/4 to 7.5 YR 5/2) silt loam; friable; single grain; boundary into underlying horizon abrupt; numerous stones at lower boundary.
D_1	40+"	Dark reddish brown (2.5 YR 3/4) to red (2.5 YR 4/6) stratified gravel and sand composed of conglomerate, sandstone and siltstone of Triassic origin.

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[5] Humus layer descriptions according to Lunt (17a).

Profile 2B

Location: Town of Ellington; on dirt road one mile [illegible] of the village of Melrose on the S side of road. Coordinates on soil profile location map (Broadbrook USGS quadrangle): No. 7;5.0-[illegible].9;6503. Sampled 4/19/54.

Topography: A 2[illegible] slope on a till plain. Elevation 330 feet above sea level.

Vegetation: Cut over forest; mainly white oak (Quercus alba L.) mixed with scarlet oak (Quercus coccinea Muenchh.).

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica, and feldspar probably derived from granite, gneiss and schist. The eolian material rest with a sharp contact on glacial till.

Sampled by: A. Ritchie, Jr. and D.B. Downs.

Horizon	Depth	Description
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1"	Organic debris partially decomposed.
A_1	1-4"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	4-16"	Strong brown (7.5 YR 5/6) silt loam; friable; weak medium subangular blocky; lower boundary grades gradually into underlying horizon.
B_{22}	16-24"	Brown (7.5 YR 4/4) silt loam; friable; very weak subangular blocky; boundary grades gradually into underlying horizon.
C_1	24-31"	Light olive gray (5 Y 6/2) to yellowish brown (10 YR 5/6) silt loam; firm; single grain; lower boundary abrupt.
D_1	31+"	Reddish brown (5 YR 4/3) fine sandy loam; very firm glacial till. The till is composed of sandstone, conglomerate, and siltstone of Triassic origin.

Profile 2C

Location: Town of Ellington; two and one-half miles [illegible] of the village of Ellington on Ellington-Somersville road on the [illegible] side of road. Coordinates on soil profile location map (Ellington USGS quadrangle): No. 3;5.2-[illegible]-0;6503. Sampled 4/19/54.

Topography: Gently rolling till plain with a 3 to 4% slope to the [illegible]. Elevation 380 feet above sea level.

Vegetation: Cut over forest; mainly white oak (Quercus alba L.) mixed with scarlet oak (Quercus coccinea Muenchh.).

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss, and schist. The eolian material rests with a sharp contact on glacial till.

Sampled by: A. Ritchie, Jr. and D.B. Downs.

Horizon	Depth	Description
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1"	Organic debris partially decomposed.
A_1	1-3"	Dark brown (7.5 YR 4/2 and 4/4) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	3-12"	Brown (7.5 YR 4/4) silt loam; friable; weak medium subangular blocky; boundary grades gradually into the underlying horizon.
B_{22}	12-20"	Brown (7.5 YR 5/4) silt loam; friable; single grained; boundary to underlying horizon abrupt; numerous red gravel in this horizon probably derived from the underlying material.
D_1	20+"	Reddish brown (5 YR 4/3) to dark reddish gray (5 YR 4/2) firm glacial till. The till is derived mainly from conglomerate, sandstone, and siltstone of Triassic origin.

Profile 2D[6]

Location:	Town of Ellington; about three miles N of the village of Ellington about one-half mile W of main dirt road on logging road. Coordinates on soil profile location map (Ellington USGS quadrangle): No.4;4.8-F.7;6503. Sampled 4/22/54.
Topography:	Gently rolling till plain with a 2 to 3% slope to the W. Elevation 430 feet above sea level.
Vegetation:	Cut over forest; mainly white oak (Quercus alba L.) mixed with gray birch (Betula populifolia Marsh), black oak (Quercus velutina Lam.) and a few eastern hemlock (Tsuga canadensis L.) and eastern white pine (Pinus Strobus L.).
Parent material:	Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss and schist. The eolian material rests with a sharp contact on glacial till.

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[6] Frequent stones 5 to 6 inches in diameter present in the profile (figure 4).

Figure 5. View of pit sampled at site 2D, Enfield silt loam (over till). Note large stones in the profile. The loess-till contact is at a depth of 24 inches. Photo taken March 22, 1954.

Figure 6a. Typical forest vegetation growing on Enfield silt loam (over till) consisting mainly of white oak, black oak and gray birch. Location near sampling site 2D. Photo taken March 22, 1954.

Figure 6b. Typical ground vegetation growing on Enfield soils (over till) consisting of Lycopodium obscurum, var. dendroideum and Lycopodium complanatum. Photo taken at sample site 2D on March 22, 1954.

Sampled by: A. Ritchie, Jr. C.L. . Swanson, T. Tamura and R.L. Hanna.

Horizon	Depth	Description
A_{00}	0-1/2"	Granular mor type Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1"	Organic debris partially decomposed.
A_1	1-3"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	3-9"	Brown (7.5 YR 4/4) to strong brown (7.5 YR 5/6) silt loam; friable; medium subangular blocky; boundary grades gradually into underlying horizon.
B_{22}	9-20"	Brown (7.5 YR 4/4) silt loam; friable; weak medium subangular blocky; boundary grades gradually into underlying horizon.
B_3	20-24"	Strong brown (7.5 YR 5/6) to brown (7.5 YR 5/4) silt loam; single grain; friable; lower boundary abrupt.
D_1	24+"	Reddish brown (5 YR 4/3) to yellowish red (5 YR 4/6) very firm glacial till. Glacial till composed of sandstone, conglomerate, and siltstone fragments of Triassic origin.

Profile 3A

Location: Town of East Windsor; one-half mile E of the village of Melrose on black top road on E side of road. Coordinates on soil profile location map (Broadbrook USGS quadrangle): No. 8;5.2-F.3;653. Sampled 4/20/54.

Topography: Strongly undulating kame terrace. Elevation 190 feet above sea level.

Vegetation: Cut over forest; mainly white oak mixed with black oak and an understory of gray birch.

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss, and schist. The eolian material rests with a sharp contact on stratified sand and gravel.

Sampled by: A. Ritchie, Jr. and D.F. Downs.

Horizon	Depth	Description
A_{00}	0-1/2"	Loose leaves and organic debris, largely undecomposed.
A_0	1/2-1"	Organic debris partially decomposed.
A_1	1-5"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	5-11"	Brown (7.5 YR 5/4) silt loam; friable; medium subangular blocky; boundary grades gradually into underlying horizon.
B_{22}	11-24"	Strong brown (7.5 YR 5/6) silt loam; friable; weak medium subangular blocky; boundary grades gradually into underlying horizon.
B_{23}	24-29"	Strong brown (7.5 YR 5/8) silt loam; friable; single grain; lower boundary irregular and fairly distinct.
C_1	29-33"	Gray brown (10 YR 5/2) spotted with yellowish brown (10 YR 5/6) silt loam; friable; single grain; lower boundary abrupt.

Horizon	Depth	Description
D_1	33"+	Reddish brown (5 YR 4/3) to yellowish red (5 YR 5/6) sand; friable; single grain.

Profile 3B

Location:	Town of Ellington; one-half mile E of Sadds Mill on State Highway 140 on N side of road. Coordinates on soil profile location map (Broadbrook USGS quadrangle): No. 5;6.3-A.2; 653. Sampled 5/6/54.
Topography:	Gently undulating kame terrace. Elevation 260 feet above sea level.
Vegetation:	Cut over forest; mainly white oak, black oak and eastern hemlock. Evidence of much tree throw in the vicinity.
Parent material:	Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss and schist. The eolian material rests with a sharp contact on stratified gravel and sand.
Sampled by:	A. Ritchie, Jr., C.L.W. Swanson, T. Tamura and R.M.Hanna.

Horizon	Depth	Description
A_{00}	0-1"	Loose leaves and organic debris, largely undecomposed.
A_0	1-1 1/2"	Organic debris partially decomposed.
A_1	1 1/2-5"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	5-15"	Brown (7.5 YR 4/4) silt loam; friable; weak medium subangular blocky; lower boundary grades gradually into the underlying horizon.
B_{22}	15-24"	Strong brown (7.5 YR 5/6) silt loam; friable; weak medium subangular blocky; lower boundary grades gradually into underlying horizon.
C_1	24-34"	Strong brown (7.5 YR 5/6) to brown (7.5 YR 5/4) silt loam; friable; single grain; lower boundary. The depth of this horizon variable, in places absent.
D_1	34+"	Reddish brown (5 YR 4/3 and 4/4) gravel and sand; single grain; loose. Outwash gravel and sand derived from sandstone, conglomerate and siltstone of Triassic origin.

Profile 3C

Location:	Town of Ellington; one and one-half miles N of the village of Ellington, one-eighth mile W of black top road. Coordinates on soil profile location map (Ellington USGS quadrangle): No. 6;6.0-B.5;6503.
Topography:	Gently sloping till plain with a 3 to 4% slope to the west. Elevation 290 feet above sea level.

Vegetation: Cut over forest; mainly white oak and scarlet oak.

Parent material: Silts and very fine sand of eolian origin composed chiefly of quartz, mica and feldspar probably derived from granite, gneiss and schist. The eolian material rests with a sharp contact on glacial till.

Sampled by: A. Ritchie, Jr., C.L.W. Swanson and R.M. Hanna.

Horizon	Depth	Description
A_{00}	1 1/2-0"	Loose leaves and organic debris, largely undecomposed.
A_0	0-1"	Organic debris partially decomposed.
A_1	1-4"	Dark brown (7.5 YR 3/2) silt loam; very friable; weak fine crumb; lower boundary irregular.
B_{21}	4-14"	Brown (7.5 YR 4/4) loam; friable; weak medium subangular blocky; boundary grades gradually into underlying horizon.
B_{22}	14-18"	Reddish brown (5 YR 4/4) to brown (7.5 YR 4/4) fine sandy loam; friable; weak medium subangular blocky; boundary grades gradually into underlying horizon.
B_3	18-24"	Reddish brown (5 YR 4/4) fine sandy loam; friable; single grain; boundary to underlying horizon not distinct.
D_1	24+"	Reddish brown (5 YR 4/3) very firm glacial till. The till is derived from sandstone, conglomerate and siltstone of Triassic origin.

4/22/55

TABLE 1. MECHANICAL ANALYSIS[1] OF ENFIELD SILT LOAM IN GRID ROW ONE

Horizon	Depth	Acidity	Size class and diameter of particles (in mm)									Mean particle size(mm)	Texture class
				Sand					Silt		Clay		
			Gravel >2	Very coarse 2-1	Coarse 1-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very fine 0.1-0.05	Coarse 0.05-0.02	Medium and fine 0.02-0.002	Clay <0.002		
	inches	pH	%	%	%	%	%	%	%	%	%		
						Profile 1A							
					(Distance from source - in source area)								
A_1	1-4	4.36	0.1	0.13	0.97	0.77	8.57	17.59	52.60	14.23	5.14	0.0634	si l
B_{21}[2]	4-12	4.58	.3	.13	.79	.85	9.98	24.77	46.82	12.89	3.75	.0650	si l
B_{22}[2]	12-23	4.63	.5	.20	.81	.94	14.49	35.65	40.33	6.22	1.34	.0857	si l
C_1	23-33	4.58	4.7	.76	2.24	1.99	27.05	38.94	26.88	1.39	.75	.1218	v f s l
D_1	33+	4.80	48.7	5.22	7.08	5.01	42.55	25.50	10.09	2.82	1.73	.2476	
						Profile 1B (overtill)[3]							
					(Distance from source area - 1 1/8 miles)								
A_0	1-0	4.4	Organic layer										
A_1	0-1/4	4.0	Highly organic										
A_1	1/4-3	4.4	0	2.2	3.8	3.9	9.6	19.9	36.0	17.8	6.8	0.1224	si l
B_{21}	3-14	4.6	5.0	1.5	2.6	2.4	5.1	16.6	45.4	20.2	6.2	.0905	si l
B_{22}	14-22	4.7	0	0.6	1.7	1.6	3.5	18.2	50.4	19.8	4.2	.0674	si l
D_1	22-36	5.2	24.0	6.6	8.6	7.3	15.9	21.9	18.6	17.1	4.0	.2435	f s l
						Profile 1C (overtill)							
					(Distance from source area - 2 1/4 miles)								
A_1	1-3	4.50	1.4	0.81	3.07	2.23	10.90	19.90	41.16	17.57	4.36	0.0993	si l
B_{21}	3-14	4.55	15.9	1.20	3.12	2.15	9.80	17.95	39.98	17.02	8.75	.0960	si l
B_{22}	14-24	4.64	8.9	1.78	3.42	2.18	9.27	19.85	43.74	15.39	4.37	.1087	si l
C_1	24-33	4.80	7.3	1.88	3.39	2.17	8.87	17.97	43.75	19.05	2.92	.1082	si l
D_1	33+	4.81	37.3	9.88	15.13	7.68	23.02	18.01	16.51	7.38	2.39	.3509	f s l

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[1] Kilmer and Alexander method (13).
[2] Average of two samples 6 feet apart.
[3] Analysis made by the Division of Soil Management, USDA laboratories, Beltsville, Maryland.

TABLE 2. MECHANICAL ANALYSIS[1] OF ENFIELD SILT LOAM IN GRID ROW TWO

			Size class and diameter of particles (in mm)										
				Sand					Silt		Clay		
Horizon	Depth inches	Acidity pH	Gravel >2 %	Very coarse 2-1 %	Coarse 1-0.5 %	Medium 0.5-0.25 %	Fine 0.25-0.1 %	Very fine 0.1-0.05 %	Coarse 0.05-0.02 %	Medium and fine 0.02-0.002 %	Clay <0.002 %	Mean particle size(mm)	Texture class
Profile 2A (Distance from source area - 3/4 mile)													
A_1[2]	1-5	4.60	0.1	0.32	1.04	0.84	3.45	12.78	49.69	21.77	10.11	0.0513	si l
B_{21}[2]	5-15	4.62	.9	.21	.97	.70	3.16	13.80	52.03	22.16	6.93	.0497	si l
B_{22}[2]	15-24	4.67	1.2	.40	.87	.72	2.88	15.45	53.10	20.20	6.37	.0527	si l
C_1[2]	24-40	5.00	3.7	.65	1.80	1.36	5.44	17.13	52.82	16.17	4.61	.0710	si l
D_1	40+	5.11	73.1	22.05	22.02	8.54	16.80	8.08	11.47	8.80	2.24	.5689	l c s
Profile 2B (overtill) (Distance from source area - 1 mile)													
A_1[2]	1-4	4.55	0	0.24	1.38	1.20	6.72	13.40	44.57	21.58	10.83	0.0585	si l
B_{21}[2]	4-16	4.51	0.2	.20	1.00	.85	5.21	13.89	47.38	20.38	11.04	.0522	si l
B_{22}[2]	16-24	4.55	0	.21	.79	.62	3.34	14.48	52.71	19.37	8.56	.0488	si l
C_1[2]	24-31	4.84	0	.11	.73	.67	3.66	15.50	54.62	20.03	4.66	.0490	si l
D_1	31+	5.13	20.7	6.24	11.22	6.24	21.54	17.64	14.82	14.45	7.95	.2589	f s l
Profile 2C (overtill) (Distance from source area - 2 1/4 miles)													
A_1[2]	1-3	4.23	1.9	2.05	6.30	4.35	15.95	16.54	29.89	18.42	6.50	0.1472	l
B_{21}[2]	3-12	4.54	11.2	1.87	5.73	3.63	13.24	15.84	35.80	15.65	8.22	.1340	si l
B_{22}[2]	12-20	4.59	17.5	3.57	6.46	3.73	13.65	16.45	37.00	14.03	5.14	.1668	si l
D_1	20+	4.97	21.6	7.41	11.53	6.56	23.44	20.08	19.03	11.75	.20	.2863	f s l
Profile 2D (overtill) (Distance from source area - 3 miles)													
A_1[2]	1-3	4.42	3.3	2.52	6.32	3.97	14.47	16.30	34.39	15.30	6.71	0.1514	si l
B_{21}[2]	3-9	4.55	7.5	2.66	5.98	3.54	13.81	15.83	33.10	16.23	8.83	.1475	si l
B_{22}[2]	9-20	4.65	15.0	4.02	7.96	4.65	16.21	16.50	29.44	14.98	6.22	.1902	l
B_3	20-24	4.75	16.2	3.15	4.77	2.68	8.67	14.06	40.91	20.34	5.42	.1354	si l
D_1	24+	5.20	26.7	6.67	9.82	5.68	19.66	16.77	21.08	17.19	3.13	.2513	f s l

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[1] Kilmer and Alexander method (13).

[2] Average of two samples 6 feet apart.

TABLE 3. MECHANICAL ANALYSIS[1] OF [illegible] SILT LOAM IN GRID ROW THREE

Horizon	Depth	Acidity	Size class and diameter of particles (in mm)									Mean particle size(mm)	Texture class
				Sand					Silt		Clay		
			Gravel >2	Very coarse 2-1	Coarse 1-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very fine 0.1-0.05	Coarse 0.05-0.02	Medium and fine 0.02-0.002	Clay <0.002		
	inches	pH	%	%	%	%	%	%	%	%	%		
						Profile 3A							
						(Distance from source area - 1/4 mile)							
A_1	1-5	4.57	0	0.30	1.46	1.12	4.73	20.12	49.67	16.78	5.82	0.0623	si l
B_{21}[2]	5-11	4.62	0	.19	1.24	.85	4.03	20.97	51.44	16.93	4.33	.0580	si l
B_{22}[2]	11-17	4.60	0	.12	.81	.54	3.70	24.36	51.97	14.80	3.63	.0545	si l
B_{23}[2]	17-24	4.64	0	.25	.97	.79	4.50	24.12	55.56	11.40	2.07	.0607	si l
B_3	24-29	4.70	0	.06	.64	.52	3.51	22.13	57.17	10.57	5.40	.0594	si l
C_1[2]	24-33	4.93	0	.18	.75	.60	4.60	25.92	57.74	9.66	1.04	.0516	si l
D_1	33+	5.40	0.3	.83	13.49	9.23	25.78	20.62	23.01	5.82	1.22	.2175	f s l
						Profile 3B							
						(Distance from source area - 1 1/2 mile)							
A_1	1-5	4.46	1.1	1.05	2.56	1.45	4.09	12.06	49.03	23.32	6.44	0.0764	si l
B_{21}[2]	5-15	4.56	3.5	1.07	2.54	1.41	4.18	12.14	49.91	21.09	7.67	.0767	**si l**
B_{22}[2]	15-24	4.76	8.3	.62	1.95	1.15	3.22	14.17	54.90	20.32	3.65	.0660	si l
C_1[2]	24-34	4.78	10.9	1.70	3.08	1.70	4.68	14.46	52.46	18.66	3.24	.0945	si l
D_1	34+	5.18	83.1	32.59	35.61	8.74	10.57	2.83	3.68	3.73	2.35	.8110	l c s
						Profile 3C (overtill)							
						(Distance from source area - 3 miles)							
A_1[2]	1-4	4.49	3.1	2.22	6.77	4.50	17.28	17.56	30.49	17.21	3.95	0.1570	l
B_{21}[2]	4-14	4.59	20.2	2.15	6.33	4.11	16.22	17.51	31.30	15.03	7.31	.1493	l
B_{22}[2]	14-18	4.66	22.0	3.76	8.69	5.07	19.11	18.97	27.48	12.18	5.18	.1993	l
B_3[2]	18-24	4.77	12.4	3.25	9.14	5.44	20.64	19.39	27.25	11.17	3.70	.1992	l
D_1	24+	4.88	21.4	5.50	10.24	6.30	23.38	20.59	19.55	12.91	1.53	.2476	f s l

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[1] Kilmer and Alexander method (13).

[2] Average of two samples 6 feet apart.

4/20/55

Particle Size Distribution

Particles >2 mm

The distribution of particles greater than 2 mm is shown in tables 1, 2, 3. The amount of particles >2 mm varies greatly among profiles and horizons. There is a tendency of >2 mm particles to increase with depth in the solum. This is not as marked in profiles where the surficial mantle is thinner.

The most significant trend is the increase in >2 mm particles in the profiles of thin loess mantle. This can be seen by comparing deep profiles of 2A, 2B and 3A with shallow profiles 2C, 2D and 3C. The solum of the profiles developed in the deeper mantle (>30 inches) were relatively free of particles >2 mm, and the solum of the profiles developed in the shallower mantle (<22 inches) are relatively abundant in particles >2 mm.

It should be pointed out that the interpretation of the distribution of particles >2 mm in the profile should be viewed with caution. Since no attempt was made in this study to separate out the size classes >2 mm, a large stone could change the values considerably and not illustrate the true situation. However, varied observations made of the >2 mm particles showed that more of the particles were of uniform size; no large particles which could introduce large errors in the calculations were observed. The consistent percentage of the >2 mm particles where present in the profiles reduces the chance that large erratics were present.

Sand separates

The amount of the sand present in the profiles is variable but tends to increase in the solum as the surficial mantle of loess thins (figures 7, 8, 9). Most of the sand fraction present in the profiles nearest the source is present in the very fine sand fraction (tables 1, 2, 3). Concretions make up a minor portion of the sand fraction.

Higher amounts of particles >2 mm in the solum are accompanied by higher amounts of sand particles, especially the coarse fractions (very coarse, coarse and medium sand) (tables 1, 2, 3). In all the profiles the fine and very fine sand make up the majority of the sand fraction with the very coarse, coarse and medium sand making up a minor portion of the sand fraction in the solums developed in loess (figure 1, 2, 3).

Silt separates

Tables 1, 2 and 3 illustrate that silt is dominant in all the profiles developed from the loess mantle. Coarse silt (0.05 - 0.02 mm) is dominant over the medium and fine silt (0.02 - 0.002 mm). The silt content tends to be highest in the profiles where the thickness of the surficial mantle of loess is greatest (figures 7, 8, 9). An increase in the sand fractions results in a corresponding decrease in the silt fraction.

There is some tendency in all the profiles for a small decrease in medium and fine silt with depth in the solum. The medium and fine silts tend to increase slightly with distance from the surface. This can be seen by comparing the C horizon of profile 3A (9.66% medium and fine silt) 1/4 mile from the source with the B_3 of profile 2D (20.34% medium and fine silt) 3 miles from the source. The amount of

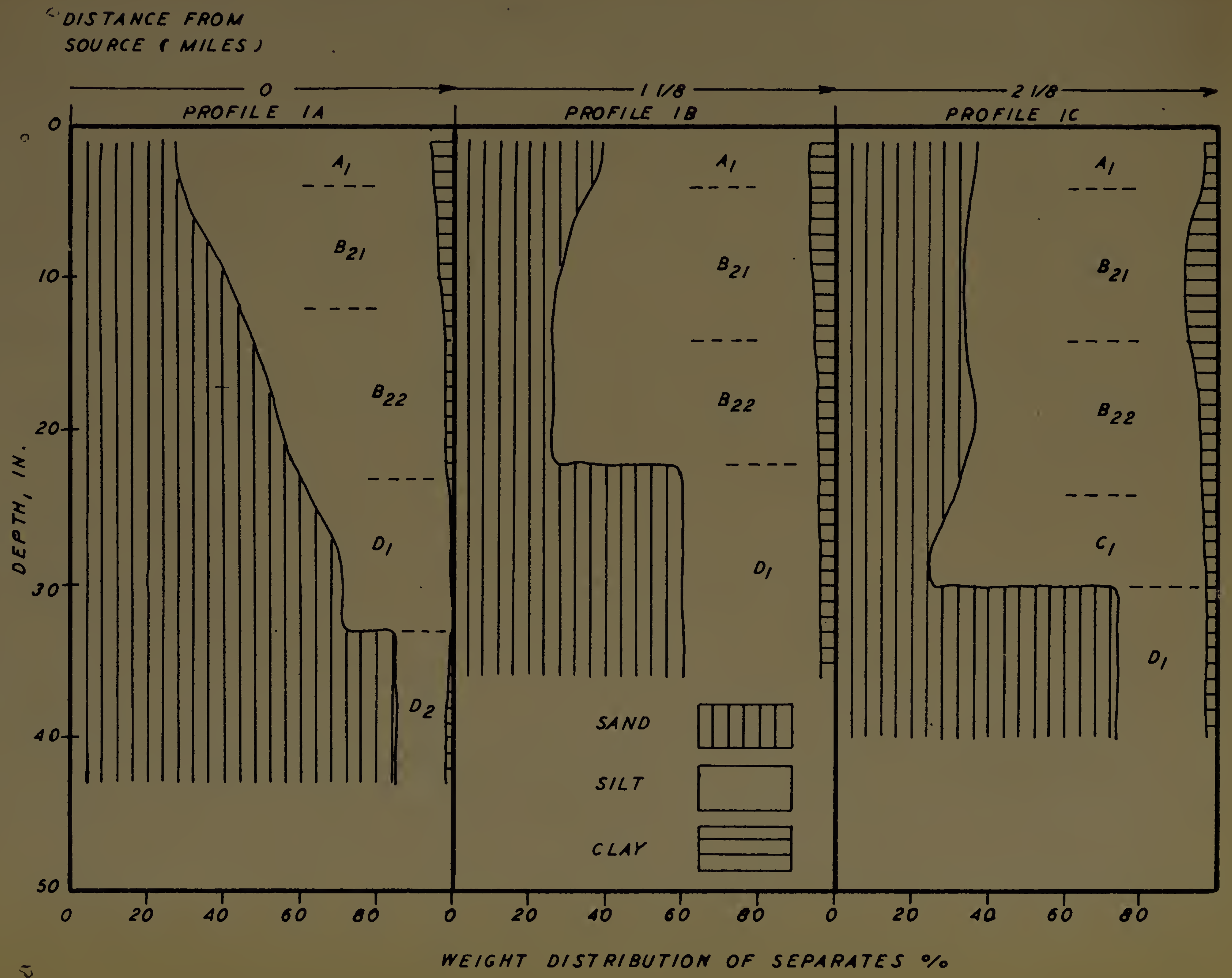

Figure 7. Distribution of sand (2-.05 mm), silt (.05-.002 mm), and clay (<0.002 mm) in the profiles in grid row one.

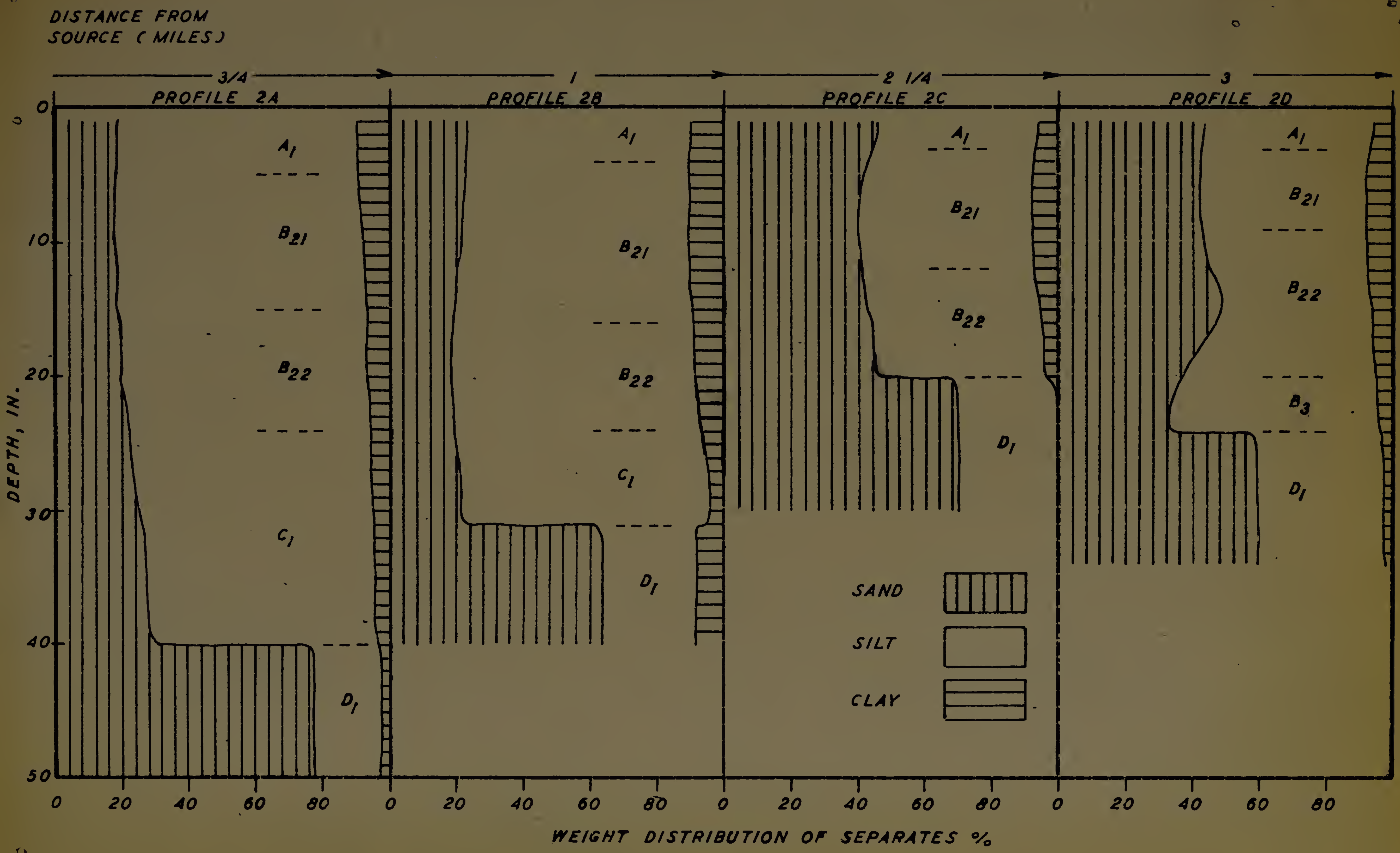

Figure 8. Distribution of sand (2-.05 mm), silt (.05-.002 mm), and clay (<0.002 mm) in the profiles in grid row two.

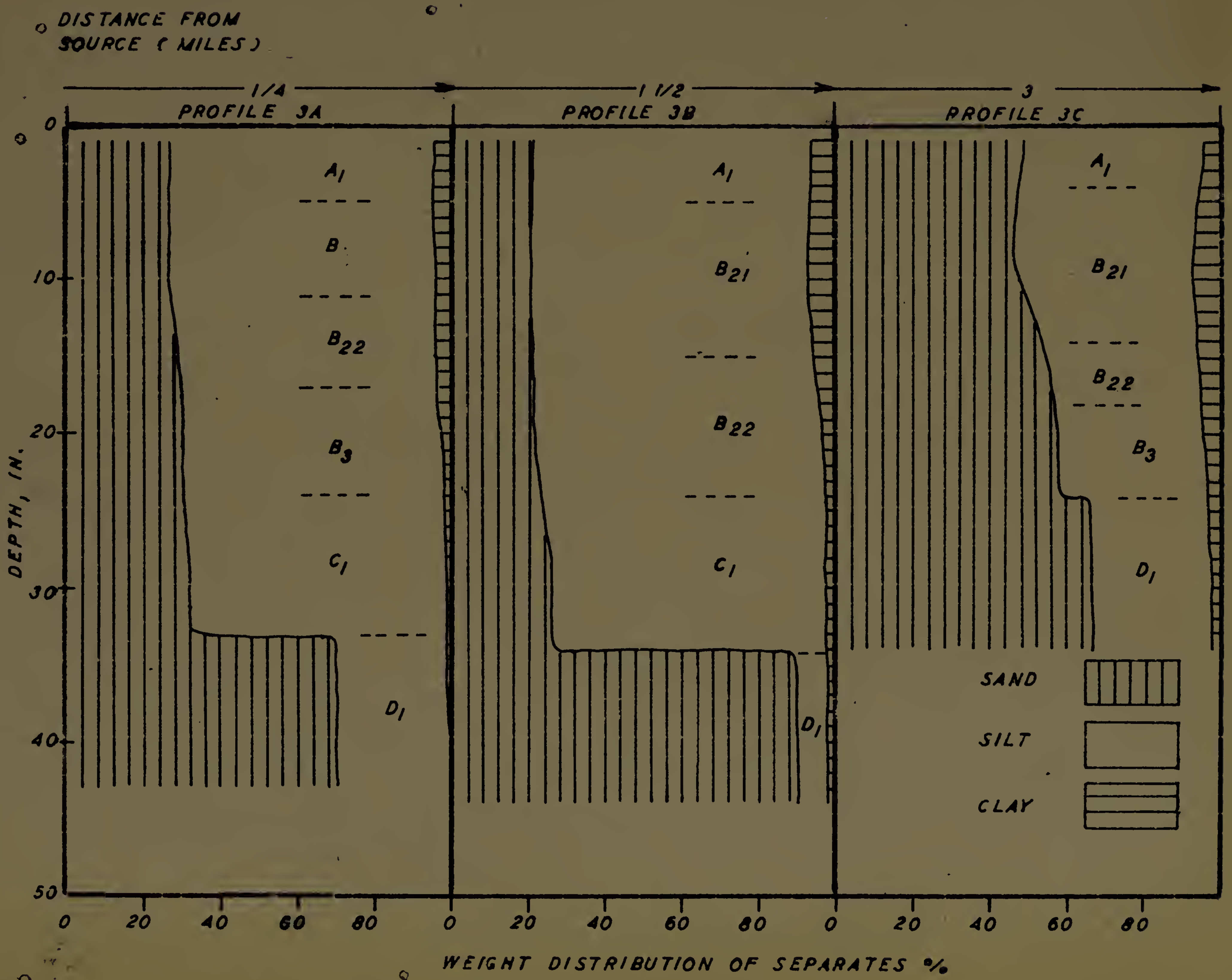

Figure 9. Distribution of sand (2-.05 mm), silt (.05-.002 mm), and clay (<0.002 mm) in the profiles in grid row three.

the silt in the D horizons is lower than the overlying profile developed in the loess in all the profiles.

Clay separates

All of the profiles are consistent in the comparatively small amount of clay they contain (tables1, 2, 3). The greatest accumulation of clay was present in the B_{21} horizon. In general the differences in clay content in the solum are so small that any trend of clay movement or accumulation is difficult to discern.

Reaction

In all profiles, the acidity gradually decreases with depth. Although there is a decrease in acidity in all the profiles, the pH of the lower horizons did not go above pH 5.4 (tables 1, 2, 3). In the A_1 horizon the mean pH value for all the profiles was 4.4; in the B_{21} horizon the mean pH value was 4.5; and in the B_{22} horizon the mean pH value was 4.6. The acid pH of the profiles is typical of Brown Podzolic soils (27). According to T. Tamura (private communication) the acid pH is one of the important properties which affect the chemical and mineralogical behavior of the Brown Podzolic soils.

Physical Relationships

Field moisture

Field moisture values vary considerably depending upon the date of sampling. In general field moisture values do not mean much unless the samples were close to field capacity when sampled. According to meteorological data, five of the profiles - 1A, 2B, 2C, 3A and 3C -

TABLE 4. PHYSICAL PROPERTIES OF ENFIELD SILT LOAM[1] IN GRID ROW ONE

Horizon	Depth sampled	Field moisture[2]	Bulk density	Porosity			Permeability		Penetrability		
				Capillary	Non-capillary	Total	Rate	Class[3]	Depth[4]	Strokes[5]	Penetration impact[6]
	inches	%	g/cc	%	%	%	in/hr		inches	no.	inches
					Profile 1A						
A_1	1 1/2-4	34.2[7]	0.78	54.7	15.6	70.3	8.6	Rapid	6.2	4.6	0.734
B_{21}	4-12	31.1[7]	1.03	48.6	11.4	60.0	3.9	Mod. rapid	5.9	7.0	.482
B_{22}	12-23	33.2[7]	1.23	44.0	8.4	52.4	1.7	Mod. rapid	4.7	11.6	.291
D_1	23-33	22.6[7]	1.45	37.9	6.1	44.0	1.2	Moderate	4.2	19.4	.174
					Profile 1B (overtill)						
A_1	1/4-3	25.9	.79	55.4	14.0	69.4	13.3	Very rapid	6.1	7.0	0.482
B_{21}	3-14	25.5	1.17	46.9	7.8	54.6	2.9	Mod. rapid	4.4	8.8	.384
B_{22}	14-22	24.0	1.35	38.6	9.5	48.1	0.8	Mod. slow	3.9	12.0	.281
D_1	22-36	13.1	1.64	29.5	6.7	36.2	1.2	Moderate	3.8	17.4	.194
					Profile 1C (overtill)						
A_1	1-3	26.0	.85	46.1	20.8	66.9	10.2	Very rapid	5.5	6.2	0.544
B_{21}	3-14	18.8	1.19	41.7	12.4	54.1	6.6	Rapid	4.9	6.9	.489
B_{22}	14-24	17.3	1.31	39.3	12.1	51.4	3.4	Mod. rapid	4.3	8.3	.407
D_1	27+	10.6	1.67	27.1	7.3	34.4	3.8	Mod. rapid	2.0	39.0	.087

[1] Average of five determinations.

[2] Moisture in soil when sampled.

[3] Soil permeability classes, Soil Survey Manual, Agriculture Handbook No. 18. 1951. USDA.

[4] Inches penetration of Roto-Tiller apparatus (1).

[5] Number of times required to lift a 12-pound hammer 2 feet to drive a 3-5/16-inch diameter core sampler 3-3/8 inches into soil (1).

[6] Average penetration of the core sampler for each impact of the 12-pound hammer.

[7] Approximately field capacity.

TABLE 5. PHYSICAL PROPERTIES OF ANTIGO SILT LOAM[1] IN GRID ROW TWO

Horizon	Depth sampled	Field moisture[2]	Bulk density	Porosity: Capillary	Porosity: Non-capillary	Porosity: Total	Permeability: Rate	Permeability: Class[3]	Penetrability: Depth[4]	Penetrability: Strokes[5]	Penetrability: Penetration/impact[6]
	inches	%	g/cc	%	%	%	in/hr		inches	no.	inches
					Profile 2A						
A_1	3/4-5	61.9	0.64	52.7	22.4	75.1	13.7	Very rapid	6.5	6.4	0.527
B_{21}	5-15	35.0	1.04	51.7	8.1	59.8	3.3	Mod. rapid	8.8	7.6	.444
B_{22}	15-24	33.9	1.17	49.2	5.5	54.7	1.2	Moderate	7.4	10.4	.325
C_1	24-40	32.3	1.24	43.5	8.3	51.8	1.0	Moderate	5.3	15.4	.219
D[8]											
					Profile 2B (overtill)						
A_1	1-4	41.7[7]	.70	48.8	23.8	72.6	13.4	Very rapid	6.6	7.2	.469
B_{21}	4-16	30.2[7]	1.10	41.9	15.4	57.3	4.5	Mod. rapid	5.7	6.8	.496
B_{22}	16-24	26.7[7]	1.33	38.3	10.1	48.4	0.8	Mod. slow	4.7	8.8	.384
D[9]											
					Profile 2C (overtill)						
A_1	1-3	30.7[7]	.86	42.5	24.2	66.7	10.6	Very rapid	7.0	4.0	.844
B_{21}	3-12	24.4[7]	1.12	39.2	21.0	60.2	5.4	Rapid	5.6	6.9	.489
B_{22}	12-20	16.3[7]	1.40	30.5	15.3	45.8	1.2	Moderate	4.2	10.8	.313
D_1	20+	11.2[7]	1.48	27.8	14.8	42.6	1.6	Moderate	3.4	19.0	.178
					Profile 2D (overtill)						
A_1	1-3	31.1	.94	48.5	14.7	63.2	14.4	Very rapid	5.2	6.2	.544
B_{21}	3-9	23.8	1.15	38.3	14.0	52.3	11.5	Very rapid	4.8	7.0	.482
B_{22}	9-20	24.2	1.31	35.1	14.5	49.6	2.0	Moderate	4.8	8.6	.392
B_3	20-24	21.9	1.40	35.9	9.9	45.8	2.0	Moderate	4.4	7.2	.469
D_1	24+	18.1	1.62	31.7	5.1	36.8	1.3	Moderate	2.8	19.2	.176

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[1] Average of five determinations.
[2] Moisture in soil when sampled.
[3] Soil permeability classes, Soil Survey Manual, Agriculture Handbook No. 18. 1951, USDA.
[4] Inches penetration of Roto-Tiller apparatus (1).
[5] Number of times required to lift a 12-pound hammer 2 feet to drive a 3-5/16-inch diameter core sampler 3-3/8 inches into soil (1).
[6] Average penetration of the core sampler for each impact of the 12-pound hammer.
[7] Approximately field capacity.
[8] D horizon core samples could not be obtained due to the loose nature of the gravel.
[9] D horizon core samples could not be obtained due to compact nature of till.

TABLE 6. PHYSICAL PROPERTIES OF [illegible] SILT LOAM[1] IN GRID ROW THREE

Horizon	Depth sampled	Field moisture[2]	Bulk density	Porosity			Permeability		Penetrability		
				Capillary	Non-capillary	Total	Rate	Class[3]	Depth[4]	Strokes[5]	Penetration/impact[6]
	inches	%	g/cc	%	%	%	in/hr		inches	no.	inches
					Profile 3A						
A_1	1-5	30.5[7]	0.85	51.9	10.7	62.6	15.4	Very rapid	6.7	4.6	0.734
B_{21}	5-11	30.4[7]	1.10	48.4	8.9	57.3	1.8	Moderate	5.0	7.2	.469
B_{22}	11-17	27.8[7]	1.16	46.3	8.9	55.2	1.9	Moderate	4.9	6.9	.489
B_3	17-24	27.1[7]	1.20	44.2	9.6	53.8	1.8	Moderate	4.3	8.0	.422
C_1	24-33	25.8[7]	1.32	45.2	3.2	48.4	1.3	Moderate	3.7	7.1	.475
D_1[8]											
					Profile 3B						
A_1	1 1/2-5	38.2	0.91	50.1	14.6	64.7	12.9	Very rapid	4.6	9.0	0.375
B_{21}	5-15	28.6	1.16	43.6	11.6	55.2	4.0	Mod. rapid	4.8	7.1	.475
B_{22}	15-24	32.3	1.26	45.0	6.4	51.4	2.6	Mod. rapid	4.2	8.3	.407
D_1[8]											
					Profile 3C (overtill)						
A_1	1-4	27.1[7]	1.04	46.4	13.1	59.5	2.5	Moderate	3.8	10.2	0.331
B_{21}	4-14	18.3[7]	1.14	36.1	19.7	55.8	3.7	Mod. rapid	5.5	4.8	.703
B_{22}	14-18	19.8[7]	1.30	37.4	12.4	49.8	1.6	Moderate	5.1	5.8	.582
B_3	18-24	14.9[7]	1.42	31.6	17.1	48.7	1.7	Moderate	3.6	8.4	.402
D_1	24+	9.7[7]	1.69	22.9	12.2	35.1	1.9	Moderate	2.0	42.8	0.079

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[1] Average of five determinations

[2] Moisture in soil when sampled.

[3] Soil permeability classes, Soil Survey Manual, Agriculture Handbook No. 18. 1951, USDA.

[4] Inches penetration of Roto-Tiller apparatus (1).

[5] Number of times required to lift a 12-pound hammer 2 feet to drive a 3-5/16-inch diameter core sampler 3-3/8-inches into soil (1).

[6] Average penetration of the core sampler for each impact of the 12-pound hammer.

[7] Approximately field capacity.

[8] D horizon core samples could not be obtained due to the loose nature of the gravel.

were close to field capacity when sampled and can be used for comparative purposes.

Field capacity indicates the amount of water held in a soil after excess gravitational water has drained and after the rate of downward movement of water has materially decreased. Most soils attain field capacity within a period of two days or less after a rain, the depth at which field capacity is attained depends on amount of rainfall.

Information on the field moisture relationships of the profiles is given in tables 4, 5, and 6. In general the highest mean value of 32.8% for field capacity was found in the A_1 horizon. There is some indication of a decrease in field capacity with depth. In the B_{21} horizon the mean value for field capacity was 26.9% and the mean value for the B_{22} horizon was 24.8%. The lowest mean value 10.5% for field capacity was obtained in the D horizon derived from glacial till. Low field capacity values would be anticipated for D horizon samples of glacial outwash sand and gravel. With increasing coarseness of texture there is a decrease in the amount of capillary pore space resulting in reduced water-holding capacity.

In profile 2B the amount of silt in the B_{21} horizon is 67.8% and the field capacity is 30.2%; in the B_{22} horizon the amount of silt is 72.3% and the field capacity is 26.7%. In profile 3C the amount of silt in the B_{21} horizon is 46.3% and the field capacity is 18.3%; in the B_{22} horizon the amount of silt is 39.7% and the field capacity is 19.8%. An increase in the coarser sand fractions (very coarse, coarse and medium sand) results in a decrease in the amount of silt present, which in turn influences field capacity. The higher field capacity for the B_{21} horizons are probably due to higher organic matter.

Bulk density

Bulk density, or apparent specific gravity, refers to the ratio between the dry weight of a given volume of soil and the weight of an equal volume of water. This value is useful in characterizing the physical conditions of a soil since, other things being equal, a low bulk density signifies a relatively porous condition and a high density signifies greater compactness. In general, the physical properties are more favorable in soils of low bulk density than in soils of high bulk density.

Bulk density values increased with depth on all the profiles (tables 4, 5, 6). The lowest bulk density value (mean value 0.83) was obtained in the A_1 horizon. This low value seems to be a reflection of the high organic matter content of this horizon. In the B_{21} the mean value for bulk density was 1.12 and the mean value for the B_{22} was 1.27. At comparable depths the D horizon samples of glacial till had a higher mean value for bulk density (1.62) than C horizon samples of loess (mean value 1.28). The higher bulk density of the D horizon samples of glacial till is a reflection of its compact nature.

Core samples could not be obtained for the glacial outwash sand and gravel constituting the D horizon of several of the profiles.

Previous experience has indicated that relatively high bulk densities (near 1.6) would have been obtained for this horizon (28). This is evident since the material of this horizon is chiefly composed of coarse material; it would not contain as much pore volume as compared to soils high in fine material. According to Lutz and Chandler (17) the presence of rock or sand in a soil favors high bulk density values whereas fine particles favor relatively low bulk density values.

The bulk density values are generally lower in the horizons containing low amounts of particles >2 mm and coarser sands (tables 1,2,3,4,5,6). In general the profiles containing lesser amounts of coarse particles tends to increase gradually in bulk density with depth. The profiles containing large amounts of coarse particles tend to increase more abruptly in bulk density with depth.

Pore volume

The pore volume of a soil is the volume of a bulk sample not occupied by solid particles. In considering pore volume it is convenient to employ the concept of capillary and noncapillary pores. Capillary pores are small and hold water by capillarity at tensions greater than 60 cm.; noncapillary pores are larger and hold water at less than 60 cm. tension.

The highest mean total porosity for all the profiles was found to be 67.4%, this value was found in the A_1 horizons. In all the profiles there was a general trend of decrease in capillary and noncapillary pore volume with depth (tables 4, 5, 6). The differences between the mean noncapillary volume between the B_{21} (13.0%) and the B_{22} (10.3%) horizons can probably be attributed to the development of soil structure. In general the B_{21} horizons have a better developed irregular blocky structure than the B_{22} horizons, thus forming larger pores (See profile descriptions, pages 19-23, 27-29). The lowest mean total porosity (37.0%) was obtained from the D horizons of glacial till origin.

There seems to be a definite correlation between capillary and noncapillary pore volume and the size fraction making up the horizons. In general the higher the silt fraction in the horizon the higher the capillary porosity and the lower the noncapillary porosity. For example, in profile 2A the amount of silt in the B_{21} horizon is 74.2 per cent, the capillary pore volume is 51.7 per cent and the noncapillary pore volume is 8.1 per cent. In profile 2C the amount of silt in the B_{21} is 51.5 per cent, the capillary pore volume is 39.2 per cent and the noncapillary pore volume is 21.0 per cent.

Permeability

The permeability rate of a soil is influenced to a marked extent by its noncapillary pore space. Soils having a large amount of noncapillary pore space generally permit rapid infiltration of water.

The permeability rate of the profiles sampled generally decreased with depth which parallels the trend of the noncapillary pore volume. The highest mean permeability rate in all the profiles was obtained in the A_1 horizons (11.4 inches per hour). According to Lutz and Chandler (17) the incorporation of organic matter in mineral soils usually increases their permeability to water as a result of increased porosity. There was no apparent correlation between permeability and the amount of particles >2 mm in any of the horizons (tables 1,2,3, 4,5,6).

The mean permeability value 1.95 inches per hour obtained for the D horizons derived from glacial till was greater than that obtained for the B_{22} horizons with a mean of 1.72 inches per hour and the C horizons with a mean of 1.23 inches per hour developed in loess. This was not anticipated since it is believed that glacial till is less permeable to water than loess. The higher permeability values for the D horizons in glacial till may have resulted from "shattering" when the core samples were obtained. One explanation for the lower permeability in the loess profile is the possible occurrence of an "incipient fragipan" in the lower B horizons. Fragipans are due to soil formation and are characterized by having lower permeability than the adjacent overlying and underlying horizons. This lower permeability is related to the arrangement of the pore spaces rather than the amount.

Penetration, strokes and penetration impact

Information on penetration, strokes and penetration impact relationships of the profiles is given in tables 4, 5 and 6. These data indicate differences between the underlying till and profile developed in the loess. Penetration is less; more strokes are required for penetration on the D horizons developed in till than the remainder of the profiles in the loess.

DISCUSSION

The following section is developed to correlate observations and data with respect to (1) differences in particle size (2) factors responsible for the dilution of the loess mantle (3) origin of the loess (4) evidence to substantiate the eolian theory (5) soil classification and mapping methods and (6) land use.

Soil Particle Size Versus Distance from the Source

Large differences among the ten profiles studied cannot be wholly attributed to particle size differentiation during deposition, as might be anticipated. There is a relationship between the distance from the source and particle size, but it is indirect.

An increase in distance from the source results in a thinning of the mantle which in turn results in an increase resemblance of the profile to the underlying material. This increased resemblance is the result of an increase in the coarse particles (particles >2 mm, very coarse, coarse and medium sand) contributed by the underlying material (D horizon) to the loess mantle. On the basis of the resemblance of these coarser particles to the underlying material and its nature, it can be concluded that these particles were derived from the underlying material, rather than deposited in the original sediment. The factors responsible for the incorporation of the coarser particles from the underlying material with the loess mantle will be discussed in detail later.

An increase in amounts of coarser particles from the underlying material in the profile results in reductions of water-holding capacity and capillary pore volume and increases in bulk density and non-capillary pore volume (tables 1,2,3,4,5,6). It is conceivable that the chemical properties may also be altered due to the mixing since the loess deposit has different origin from the underlying glacial till and outwash.

Mean Particle Size and Degree of Mixing

The mean particle size values (tables 1, 2, 3) can be used to get an idea of the relative amount of mixing of particles with the underlying material and the change in particle size of the eolian material with distance from source. Profiles 1A, 2A, 2B and 3A show horizons which are relatively free of mixing. In profile 1A this is true only in the A_1 and B_{21} horizons; the mean particle size is approximately 0.064 mm. The B_{22}, C_1 and D_1 horizons of profile 1A are believed to be of water deposition origin. This profile was sampled in the source area. In profile 3A (1/4 mile from source area) the average mean particle size value of the solum is 0.058 mm. In profile 2A (3/4 mile from source area) the average mean value from the solum is 0.056 mm; if the C_1 horizon is omitted from the average mean calculation (C horizon exhibits slight mixing) the average mean particle size for the A and B horizons is 0.051 mm. In profile 2B (one mile from source area) the average mean value of the solum is 0.052 mm. The data show the particle size decreasing with increasing distance from the source for the unmixed profiles.

The remaining profiles show various amounts of mixing; consequently, changes in mean particle size with distance cannot be easily ascertained.

Since the mean particle size of the unmixed horizons does not vary greatly with profile depth calculations may be made to determine semi-quantitatively the degree of mixing. In selecting the limits of loess and till the mean particle size of the till underlying the particular profile was selected. The mean value from profile 2B was used for the eolian component since this mean value represents the greatest distance from the source. The mean particle size of the loess was used to represent no mixing and the mean value of the underlying till was used as 100 per cent mixing. The further the mean particle size of a horizon developed in the loess mantle diverges from that of pure loess and the closer it approaches that of the underlying material (D horizon) the greater the mixing.

For example, if the B_{22} horizon for profile 2C is compared with profile 2B representing pure loess and the D horizon of 2C, the degree of mixing (till influence) is found to be approximately 50 per cent. The example is shown below.

Profile	Horizon	Mean particle size (mm)	Difference (mm)	%
2B	Solum (unmixed)	0.0520		0
			0.1148	50
2C	B_{22} (mixed)	0.1668		
			0.1195	
2C	D_1 (unmixed)	0.2863		100

The calculations to express the degree of till and outwash influence are shown in table 7.

The greatest amount of mixing is found in profiles 2D and 3C, both profiles are farthest from the source area. The A_1 and B_{21}

TABLE 7. SEMI-QUANTITATIVE DEGREE OF MIXING OF ENFIELD SOILS STUDIED

Sample No.	Horizon	Per cent till influence	Sample No.	Horizon	Per cent till influence
1A	A_1	0	2C	A_1	41
	B_{21}	0		B_{21}	37
1B	A_1	36		B_{22}	50
	B_{21}	20	2D	A_1	50
	B_{22}	8		B_{21}	48
1C	A_1	16		B_{22}	70
	B_{21}	16		B_3	42
	B_{22}	19	3A	A_1	0
	C_1	19		B_{21}	0
2A	A_1	0		B_{22}	0
	B_{21}	0		B_3	0
	B_{22}	0		C_1	0
	C_1	0	3B	A_1	4
2B	A_1	0		B_{21}	4
	B_{21}	0		B_{22}	2
	B_{22}	0		C_1	7
	C_1	0	3C	A_1	53
				B_{21}	50
				B_{22}	75
				B_3	75

horizons of both profiles are mixed approximately 50 per cent. The B_{22} horizons and the B_3 horizon of profile 3C are mixed approximately 75 per cent. The B_3 horizon of profile 2D is only 42 per cent mixed: this discrepancy is due to the nature of the sample in the pit. This horizon is actually a "pocket" in the sediment and show distinct features not yet correlated with the sediment. Profile 1C and 2C show intermediate degrees of mixing; 1C is approximately 20 per cent mixed and 2C approximately 40 per cent mixed. Profile 3B is underlain by glacial outwash. It would be expected that the loose nature of this deposit would be less conducive to mixing by frost action because of its better drainage. This is shown by the very low degree of mixing in profile 3B (approximately 5%).

In spite of 50% mixing such as in profile 2C the contact between the loess and underlying till was relatively distinct. In profile 3C where there is up to 75% mixing the contact was observable but indistinct.

Particle Size Differences Due to Weathering

There appears to be no great differences in particle size as a result of weathering in any of the profiles studied. In general these soils can be said to lack textural development. This is exemplified by considering the mean particle size in 2A, 2B and 3A which are profiles with very little mixing (tables 1, 2, 3). These profiles are characterized by having a uniform mean particle size throughout the solum. According to Swanson et al. (27) and Lyford (18) Brown Podzolic soils in the Central Lowland are characterized by little textural profile development; the B horizon is only slightly, if any, finer textured than the A horizon.

The lower amount of clay in the C horizons compared to the rest of the solum developed in the loess seems to reflect the reduced weathering in this horizon. Unpublished clay mineral data from The Connecticut Agricultural Experiment Station indicate that the C horizon samples in this study are relatively unweathered and that the B horizon has developed from the C horizon material. This tends to rule out the possibility that the B horizon had a higher clay content as a result of deposition rather than as a result of weathering.

Factors Responsible for Mixing

It is not unusual to observe the presence of fair-sized pebbles well up in the body of the fine-grained loess, as well as the presence of coarser particles in the various loess profiles studied. The mixing of fragments from underlying glacial deposits with eolian deposits in the Central Lowland has also been pointed out by Swanson et al. (27). In some parts of the Central Lowland thin deposits of loess are difficult to recognize in the field since they have been incorporated with the underlying material. The mixing of the underlying material with the loess may be due to various factors, working singly or jointly.

Smith and Fraser (24) have attributed the introduction of foreign material from the substratum into the overlying loess body to be partly due to frost action (congeliturbation (3)). The occurrence of ventifacts in the loess body below the present surface in the Mt. Toby Quadrangle has been thought to be a result of the churning action of frost (12). This churning effect of frost action may have taken place during or following its deposition. On the basis of this study it is difficult to say when the mixing by frost action took place. It is conceivable that much of the mixing could have taken place after deposition in the deposits which formed rapidly and during deposition in the deposits which formed slowly. The absence of loess in some areas in New England has been explained by the fact that loess was incorporated into the surface by frost action as fast as deposited (2).

In addition to the freezing and thawing phenomenon associated with frost action, the nature of the underlying material should be considered. Profiles underlain by outwash would permit free flow of water through the large pores and thus have less effect on freezing and thawing than the underlying till. In profiles 3B and 1C both are of the same depth but 3B is underlain by glacial outwash and 1C is underlain by glacial till. The degree of mixing as calculated in table 7 shows approximately 15% in the upper part and 20% in the lower part of the solum of the profile underlain by till and approximately 5% mixing in the entire solum of the profile underlain by glacial outwash.

Uprooting of trees is a universal phenomenon in forest regions (figure 10). Over long periods of time the soil under forest stands may repeatedly be subject to disturbance when trees are uprooted (16).

Figure 10. View of a tree that has been windthrown on Enfield silt loam. This tree was probably windthrown during the hurricanes of 1936 or 1938. Note the stones mixed with the soil profile developed in the loess. Location near sampling site 3B. Photo taken April 18, 1955.

It is not difficult to visualize the incorporation of loess with the underlying deposits by this action. Stout (25) believes that coarser material is further mixed with the overlying loess by tree throw after the former had previously been added by frost action.

Another factor responsible for mixing has been presented by Smith and Fraser (24). They believe that rain wash on hill sides probably played a part in moving the silt downslope and mixing it with extraneous material. This factor could play a part in mixing before vegetation became established; but after vegetative growth it is doubtful if much of this type of mixing occurred.

The possible mixing of soil materials by the higher animals is still another possible explanation for part of the mixing. According to Lutz and Chandler (17) "Many animals burrow in the soil and over a period of years accomplish considerable work. Material from the subsoil horizon is brought up; and surface material, both organic and inorganic, either is carried down or gradually worked down by gravity".

Local Origin of Loess

Several workers (8, 11) have regarded glacial fluvial and lacustrine deposits as the main source of loess and sand dunes in New England. These deposits were desirable since they were unvegetated during a time of much wind activity and they furnished a desirable particle size which could be easily transported. The Central Lowland of Connecticut and Massachusetts contains an abundance of glacial fluvial and lacustrine deposits. Hence, it is not inconceivable to to visualize the Central Lowland as a good source area offering a wide unobstructed area for wind action.

The change in mean particle size from 0.064 to 0.052 mm within a distance of one mile from each other would tend to locate the source very near to the profile with the highest mean particle size. If the source area was a great distance away one would not expect to find the size separation as was found in this study.

The winds which caused deposition of the loess were probably from a westerly direction. It is difficult to assign a direction to the wind which was responsible for the deposition of the loess since the loess deposits do not extend a long distance from the source area.

Dunes located to the west of the area which are influenced by the loess indicate a prevailing northwesterly direction to the wind. It has been argued by Flint (private communication) that a northwesterly direction indicated by the dunes may not be applicable to the loess since he believes that the dunes may have been deposited long after the deposition of the loess.

Present Day Observations of Loess

An idea of the way in which the loess developed can be gained on a windy day by observing tobacco fields without a cover crop. On January 19 and 21, 1955 strong winds blowing from a northerly direction whipped up considerable dust from tobacco fields in the Hadley area. At times visibility was greatly reduced. Considerable dust was blown as far as the campus of the University of Massachusetts a distance of one to three miles.

Evidence to Substantiate Wind-borne Origin of the Surficial Mantle

During this study some evidence was obtained which would substantiate wind-borne origin of the surficial mantle in which the soil profiles were developed. The presentation of this evidence is desirable since some people still question wind action as being responsible for the formation of this deposit. The characteristics of the surficial mantle in this study which fit "Criteria for the wind-borne origin of fine-grained deposits" as proposed by Smith and Fraser (24), will be presented in the following discussion.

The mantle tends to conform closely to the general contour of the pre-depositional surface, filling in depressions and thinning on hilltops. There is a tendency for the mantle to be thicker on the leeward sides of hills than on their windward sides. The presence of the mantle is generally independent of elevation.

The undisturbed mantle rests with a sharp contact on the underlying material and shows no resemblance to it. It lacks stratification and is generally uniform in character (see tables 1, 2, 3 for mean particle size of profiles).

There is a slight degree of sorting of particles due to deposition. A slightly higher amount of very fine sand is present in the mantle nearest the source with a slight decrease away from the source (tables 1, 2,3 and discussion under "Particle Size and Degree of Mixing"). As a result of the short distance from the source it is not surprising that there was no more sorting than indicated by the samples. There is a predominance of particles 2 to 50 microns (silt) in the mantle, which according to Flint (9) is characteristic for loess. The mantle shows a definite thinning with increased distance from the source, approximately three feet to 18 inches or less.

There is a distinct color difference between the mantle and the underlying material (see profile descriptions). The unweathered mantle is generally gray brown (10 YR 5/2) to yellowish brown (10 YR 5/6) and the till is reddish brown (5 YR 4/4) to dark reddish brown (5 YR 3/3). The weathered loess (B horizon) is brown (7.5 YR 4/4) to strong brown (7.5 YR 5/6).

The occurrence of dunes to the west of the area covered by the surficial mantle has been discussed earlier. These dunes are indicative of wind action but the question remains as to whether the dunes formed at the same time as the loess. The presence of ventifacts in certain parts of the Central Lowland may also be used to indicate wind activity.

Classification and Mapping of the Enfield Series

Fundamentally, soil classification serves as the basis for classifying, synthesizing and reporting results of research and experience. It is believed that the results from this study can be synthesized and applied to a more efficient and intelligent management of loess-derived soils in the whole of New England.

The results obtained in this study indicate the nonuniform nature of the characteristics of the Enfield series. Although these variations may not be sufficient to warrant the formation of new series, they do warrant the use of phase separations. Lack of uniformity was found in

(1) depth of the loess mantle over the underlying material (2) type of underlying material (3) topography (4) profile texture (5) color and (6) stoniness. It is important at this time to outline how these variations in characteristics were classified into mapping units in the Hartford County, Connecticut soil survey (5). These mapping units may be useful in the classification of other loess derived soils in New England.

Deep and shallow phase

One of the most important separations within the Enfield series is the depth of the loess over the underlying material. This separation constitutes two subdivisions (1) the deep phase and (2) the shallow phase. The deep phase ranged from 18 inches or more in depth and the shallow phase ranged from less than 18 inches to the underlying material. The break between the deep and shallow phase is an arbitrary one determined in the field by mapping experience. It is possible that these mapping ranges could be changed when more evidence on crop response is available.

The color of the solum of the deep phase is restricted to 7.5 YR hues or lighter. Although the solum color of the shallow phase is restricted to these hues there is some tendency for the lower portion of the solum to be near the 5 YR hues. This reddish color was derived from the underlying material due to mixing.

The mechanical analysis show most of the samples to be a silt loam[1]. At present it is believed that most of the Enfield soils

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[1] Texture designations from Soil Survey Manual, Soil Survey Staff, U.S.D.A. Agr. Handbook No. 18. 1951.

on the east side of the Central Lowland are silt loams. Formerly the dominant texture of the Enfield soils was thought to be a very fine sandy loam. There is a tendency for the profiles of the shallow phase to be near a loam texture.

Glacial till and outwash phases

The loess has been observed to blanket glacial till, glacial outwash and bedrock. At the present time there are two mapping separations based on the underlying material. The Enfield soils underlain by till are separated from those underlain by outwash sand and gravel.

The loess over till is generally situated on undulating to rolling till plain. The deep phase Enfield over outwash is generally situated on nearly level to very gently sloping terraces and the shallow phase is generally situated on irregular kame terraces with short abrupt slopes.

Land Use

Loess derived soils are characterized by having almost ideal physical conditions for plant growth (20). These soils exhibit a high water holding capacity, are easy to cultivate, and produce high yields of crops of excellent quality with adequate fertilizer in years of normal rainfall. Tobacco is especially suited to this soil. Good results are obtained with general field crops and vegetables. Exceptionally good potato fields are found on these soils.

The deeper rooted crops such as alfalfa may grow more favorably where the loess profile is underlain by glacial outwash sand and gravel rather than by glacial till. The underlying till may restrict root development due to its compact nature and possible formation of a perched water table condition.

The reduction in the downward movement of water in the loess profiles underlain by till may be favorable in some instances. There would be less tendency for fertilizer losses due to leaching and for less rapid loss of moisture due to gravity.

Erosion is a problem on the Enfield soils under clean cultivation, especially on slopes of more than 3 per cent. Erosion may develop to the degree that it has reduced or threatened the productivity of the land.

The chief objection by farmers to the loess soil over till is the problem of stones (figure 11). In some instances this land is left to pasture or forest because of the problem of stone removal.

A high per cent of the Enfield soils underlain by outwash are occupied by tobacco, although some of these soils are utilized for potatoes and alfalfa. The Enfield soils underlain by till are used more for potatoes and general field crops than for tobacco (figure 12) but they are still used for tobacco to some extent (figure 13).

Figure 11. View of stones removed from a field of Enfield silt loam (over till) recently brought into cultivation. The stones consist of sandstone and conglomerate of Triassic origin. Photo taken near sample site 2B on March, 1954.

Figure 12. View of Enfield silt loam (over till) on gently sloping till plain cropped to alfalfa in the foreground and corn in the background. Photo taken near Ellington, Connecticut on August 6, 1953.

Figure 13. View of Enfield silt loam (over till) on gently sloping topography cropped to Broadleaf tobacco in foreground and Shade tobacco in background. Photo taken near Ellington, Connecticut on August 6, 1953.

SUMMARY AND CONCLUSIONS

Field and laboratory studies were made on soils derived from the loess in the Central Lowland of Connecticut and Massachusetts. Field studies were made to determine (1) the area distribution of the soils influenced by the loess (2) the topographic distribution of the loess and (3) the depth of the loess mantle. Laboratory samples were obtained from ten sample pits located on a grid in an area strongly influenced by loess. In the laboratory the mechanical composition of the samples was determined by the pipette method. Other analyses made included field moisture, total porosity, bulk density, permeability, penetration and pH. The conclusions reached may be summarized as follows:

(1) The surficial mantle studied was deposited due to eolian action.

(2) The loess mantle originated from glacial lacustrine and fluvial deposits within the Central Lowland.

(3) The loess mantle decreases in depth with increasing distance from the source. The mantle thins from three feet to 18 inches within three miles distance.

(4) There is an increase in coarser particles with distance from the source area due to mixing. The greatest amount of mixing occurred 3 miles from the source area with approximately 75 per cent till contribution in the lower part of the solum and 50 per cent in the upper part (profiles 2D and 3C).

(5) A decrease in mean particle size was found in the profiles exhibiting no mixing, from 0.064 mm at the source to 0.052 mm one mile away from the source.

(6) Differences in the clay content in the different horizons of the profiles are the result of weathering and not deposition.

(7) Mixing is sufficiently intense in many of the profiles developed where the loess mantle is shallow so that its influence on particle size on the horizons is decreased tremendously.

(8) The greater the coarser particles mixed with the profiles developed on the loess mantle the greater the reduction in water-holding capacity also the effect of the coarser particles were detrimental to other physical characteristics which influence plant growth.

(9) The classification of these soils is necessary so that their characteristics can be applied to the interpretation of data obtained from laboratory and field plot experiments.

(10) The presence of the coarser particles in the loess mantle is believed to be a result of mixing of the underlying material with the loess mantle by frost action, tree throw, rain wash and animal activity.

(11) Most of the loess derived soils on the east side of the Central Lowland are of a silt loam texture rather than a very fine sandy loam texture as was formerly believed.

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