CLAY DEPOSITS OF THE CONNECTICUT RIVER VALLEY, CONNECTICUT

A SPECIAL PROBLEM IN LAND MANAGEMENT

by

William H. Langer

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7. Clay deposits of the Connecticut River Valley, Connecticut--a special problem in land management, by William H. Langer. 39 p., 13 pl., 3 figs.

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CLAY DEPOSITS OF THE CONNECTICUT RIVER VALLEY, CONNECTICUT

A SPECIAL PROBLEM IN LAND MANAGEMENT

by

William H. Langer

ABSTRACT

When man first settled the United States, two natural features favored settlement; flat land that was easy to build on and to farm, and a nearby river that could act as a source of water, transportation, and power. The Connecticut River Valley from Middletown, Ct. north past the Connecticut-Massachusetts state line satisfied these two needs, and was favored by many early Americans in New England. This area remains an area of rapid urbanization, partly because of the broad flat lowlands.

The subdued topography of this area is due in large part to deposition of fine-grained materials into glacial Lake Hitchcock. This lake was formed during the Wisconsinan age when southward drainage in the Triassic valley of Connecticut was dammed by glacial drift in the area of Rocky Hill, Connecticut. Lake Hitchcock grew to and beyond St. Johnsbury, Vt. with much of the lake being filled with cyclical lake-bottom deposits during the 2,290 to 2,350 years of its life.

Aside from the relative flatness inherent in the deposition of fine-grained lake-bottom deposits, these deposits present very few characteristics that are favorable for urbanization. Favorable characteristics are possible sources of clay for manufacturing and possible sources

for waste storage sites. Unfavorable characteristics include low water yields resulting in poor urban water-supply sources, and very low flows in streams during dry periods; low percolation rates resulting in drainage and septic problems; and low or uneven bearing strength which create problems in construction.

Fine-grained lake-bottom deposits have been mapped for six quadrangles in the Connecticut Valley lowlands; the quadrangles of Windsor Locks, Broad Brook, Hartford North, Manchester, Hartford South, and Glastonbury (all located in Connecticut). All the maps were prepared from existing information including well and test hole data on file at the Water Resources Division in Hartford, surficial geologic quadrangle maps, and bedrock contour maps. The maps also reflect geologic interpretations of the history of glacial Lake Hitchcock.

The Hartford North maps were prepared as test maps to determine if the project was feasible. They were prepared using the previously described information plus additional subsurface data obtained from engineering firms and the State Highway Department.

During preparation of the maps, an arcuate-shaped, ice-contact deposit composed of coarse sand and gravel was delineated in the Broad Brook and Windsor Locks quadrangles. This feature marks the location of a zone of stagnant ice in front of and marginal to active ice to the north.

Two types of maps were prepared for the area in study; Thickness of the Principal Clay Deposit, and Thickness of Material Overlying the Principal Clay Deposit. The term "principal clay deposit" refers to the fine-grained lake-bottom deposits of Glacial Lake Hitchcock. These maps define the distribution of the deposit, and show the thickness of the deposit in 50 foot intervals and the thickness of the material overlying the deposit in 20 foot intervals. The maps indicate that much of the area is underlain with substantial thicknesses of fine-grained lake-bottom deposits (50 feet thick or greater), and that much of the deposit is within 20 feet of the surface.

The maps included in this report can be used for land-use planning. Uses include location of favorable sites for specific uses such as landfills, utility corridors, heavy construction, etc; location of problem areas for specific land uses; identification of possible problems for specific areas; design and construction cost estimates; and prospecting for exploitable clay deposits. It is suggested that, for effective planning, these maps be used together or in conjunction with other maps such as maps showing surface materials, depth to bedrock, depth to water table, and flood prone areas.

TABLE OF CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

TABLE

INTRODUCTION

When man was first settling the United States, there were two natural features that made an area quite favorable for settlement. These features were flat land that was easy to build on and to farm, and a nearby river that could act as a source of water, transportation, and power. The valley of the Connecticut River from Middletown, Ct. north past the Connecticut-Massachusetts state line, was one area that satisified these two needs. As a result, this area was favored by many early Americans in New England. The Hartford area, at the junction of the Connecticut River with the Farmington, Hockanum, and Park Rivers, became the most rapidly expanding center in the area.

Partly as a result of the initial growth in the Hartford area, the Connecticut Valley remains a focus of rapid urbanization. One of the main reasons for the continued rapid growth is the same reason as in early times; the broad flat lowlands. The flatness of the Connecticut River Valley is due in large part to two geologic factors. First, almost all of the area is located in a structural valley underlain with relatively low resistant sedimentary bedrock. Second is the important affect that glaciation had on the area.

The pre-glacial and glacial history of this area has been included in Part I of this report for the convenience of people not familiar with this history. Part I also includes a description of the principal clay deposit and its effects on urbanization. It has been written in terms that should be familiar to non-scientifically oriented persons as well as to the scientist. Part II consists of a detailed discussion of the procedures used to map the principal clay deposit, and describes a feature that is interpreted to be an ice-front feature marking a temporary halt in the recession of the ice. Part III discusses some of the uses and applications of the maps included in this report.

Thirteen plates are included in this report. Plates 1-12 are 1:24000 scale maps; plates 1-6 are maps of the thickness of the principal clay deposit, and plates 7-12 are maps of the thickness of material overlying the principal clay deposit. Plate 13 is a compilation of the distribution of the principal clay deposit at a scale of 1:125000. Plate 13 is also an index map locating geographical names used in the report and should be referred to while reading the report.

PART I

PRE-GLACIAL HISTORY

Just prior to the Triassic Period, this area might have looked much like the eastern upland areas of Connecticut. Then, approximately 200 million years ago, during the Triassic Period, this area underwent major geological changes. Faulting took place, and the region started to subside, with subsidence greater on the east side of the area than on the west. Numerous rivers began draining into this area, depositing clay, silt, sand and gravel in the newly created valley. As more sediments were deposited, the increased load changed clay and silt into shales and siltstones, sands into sandstones, and gravels into conglomerates, by compaction and cementation. Faulting took place, and the increased relief renewed the erosion and sedimentation processes. This sequence of sedimentation, consolidation and faulting continued throughout the Triassic Period. Three different times during this period, the process was interrupted by lava flows which solidified into the resistant trap ridges that are still seen today (Deane, 1967). The sequence of deposition can be seen in Table 1.

During the many millions of years that followed, the valley was not subjected to great tectonic activity. Instead, it underwent erosion, with rivers forming deep valleys where they cut down through the rocks. Many of the valleys were cut into the weaker shales, while the more resistant sandstones, conglomerates and basalt (trap rock) formed ridges in the bedrock. This erosion continued until sometime

Table 1. Triassic stratigraphy of Connecticut (modified after Klein, 1968).

Formation	Lithologies	Thickness	Environments
Portland Arkose	Fanglomerate, arkosic sandstone, mudstone	greater than 1,475 feet	Alluvial fan, floodplain
MERIDEN GROUP			
Hampden Basalt	Basaltic lava	328 feet	Flood basalt
East Berlin Formation	Siltstone, mudstone, sandstone, claystone	630-1,590 feet	Lake and alluvial mudflat intertonguing into alluvial far
Holyoke Basalt	Basaltic lava	656 feet	Flood basalt
Shuttle Meadow Formation	Siltstone, mudstone, sandstone, claystone	312-902 feet	Lake, alluvial mudflats, alluvial fans
Talcott Formation	Basaltic lava and interbedded sandstone, mudstone	492 feet	Lake, alluvial fan, Flood basalt
New Haven Arkose	Fanglomerate, arkosic sandstone, mudstone	10,988 feet	Alluvial fans, floodplains

in the Pleistocene Epoch, which began roughly a million years ago.

GLACIAL HISTORY

During the Pleistocene Epoch, a world-wide decrease in temperature took place, resulting in a series of glaciations (Flint, 1971) with massive ice sheets flowing southward across the northern part of the North American continent. Buried soils and other stratigraphic evidence support the idea of multiple glaciation in the mid-west. In New England, such evidence is less clear, but the widespread occurrence of two texturally and structurally distinct tills has been interpreted to support multiple glaciation in New England also (Pessl and Schafer, 1968). [1] Even though ice advanced over this area a number of times, most of the glacial deposits that remain result from the last glaciation, the Wisconsinan stage. Approximately 20,000 years ago (Schafer and Hartshorn, 1965) the Laurentide Ice Sheet of Wisconsinan age, grew from the highlands of Canada and spread southward across the entire New England area, all the way to Long Island. This ice moved roughly from north to south, but as it thinned, evidence from striations and streamlined molded hills (drumlins) show it was controlled somewhat by local topography. In the Connecticut Valley region, the ice only modified the existing landscape, mostly by deepening of bedrock valleys and by removing the previously existing unconsolidated materials. In fact, the pre-glacial drainage network that was eroded into the bedrock can be inferred from the bedrock

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1) Some geologists believe that these two tills do not represent a difference in age, but instead represent a difference in mode of implacement. However, the more recent detailed work supports the theory that the tills are of different ages.

surface. Apparently the Connecticut River, in the area near Windsor Locks, Ct. flowed in a now buried channel a few miles east of this area during pre-glacial times (Flint, 1933).

The ice sheet was thick enough to cover all the mountains and adjoining areas of New England. Since the ice covered the Hanging Hills in the Meridan quadrangle-altitude 976 feet (Hanshaw, 1962), and Lamentation Mtn.-altitude 720 feet, Beseck Mtn.-altitude 845 feet, and Higby Mtn.-altitude 892 feet, in the Middletown area (Deane, 1967), and since the bedrock surface is deeper than 250 feet below sea level in places near Hartford and East Hartford (Ryder, 1972), it can be inferred that the ice was at least 1,200 feet thick in this area. Evidence from other areas in Connecticut indicate that the ice was at least 2,500 feet thick ~~in Connecticut~~ (Flint, 1930).

Near the end of glaciation, the leading edge of the ice sheet began melting faster than its rate of advance. This in effect, caused the ice sheet to retreat northward. There is evidence that the ice may have readvanced at least once during this general period of retreat. In Berlin, varved clay has been deformed by the overriding ice (Deane, 1967). These clays are covered with till, which strongly indicates a readvance of the ice.

During this period of wastage, the melting ice took on a special aspect. As the ice melted, the higher topographic areas began to appear through the surface of the ice. As the ice continued to melt, much of the upland area became free of ice, while a giant tongue of ice remained in the Connecticut Valley lowland. Since the ice was still moving southward, (although the ice front retreated due to rapid melting), it acted as a giant conveyor belt, continually supplying new material to the area. This material was then deposited, either directly by the ice as till, or by water as stratified drift deposits.

Between 14,000 years BP (before the present) and 13,500 years BP, the ice front had retreated to a position a few miles north of Middletown, readvanced to a position near Middletown, and then retreated to a position in the vicinity of Rocky Hill, Connecticut (Hartshorn, 1969). As the ice sheet retreated, a great body of stratified drift was deposited with its head near Rocky Hill. 2) As the ice continued to melt, a lake called Lake Hitchcock, formed behind the dam. Outflow from this lake eroded a shallow channel through the area of Dividend Brook (Hartshorn, 1969). As the ice retreated, it opened up other spillways, each at successively lower altitudes. When the ice front retreated somewhere past Cedar Mountain in Hartford, a new channel opened up. The water flowed around the north end of Cedar Mountain and out through a spillway in New Britain. This spillway, which first flowed on unconsolidated material, and later on bedrock, remained as the spillway for the life of Lake Hitchcock.

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2) This drift deposit may have formed as a delta or a series of deltas into a lake created by a drift dam below Middletown. The level of this lake was probably controlled by a spillway located in the Jobs Pond area in Portland.

The lake continued to enlarge as the ice front retreated northward. The ice front assumed a lobate shape, extending further into the lake in the central area, and melting back more rapidly at the margins. As the ice retreated, it opened up the way for sediment-loaded rivers to drain into the lake. Upon entering the lake, some of these rivers deposited the sediment in the form of deltas extending out into the lake.

The lake continued to grow northward to and beyond St. Johnsbury, Vermont (Hartshorn, 1969). As the lake grew, fine-grained deposits were carried to the lake by the water issuing from the melting ice. During the summer, the melting of the ice was more rapid than in the winter. This increase in flow kept the lake waters in motion. This slight agitation of the water kept the clay-sized particles in suspension, whereas the heavier silt-sized and very fine-grained sand-sized particles settled to the bottom of the lake. During the winter, the lake may have been covered with ice, thus reducing the water motion. Also, the melting of the glacial ice was much slower or maybe even completely stopped, which also helped keep the water quiet. During this period when the lake waters were quiet, the fine-grained clay-sized particles settled out of suspension. This separation of particle sizes created a sequence of alternating layers of clay with silt and very fine-grained sands called varves. These fine-grained lake-bottom deposits make up the bulk of the materials that were deposited into glacial Lake Hitchcock.

Sometime between 10,710 BP and 10,650 BP, the dam at Rocky Hill was breeched, and Lake Hitchcock was drained (Flint, 1956). The age of the lake when it was drained is not known; however radiocarbon dating shows that it had a life of between 2,290 and 2,350 years (Schafer and Hartshorn, 1965).

As the lake started draining, currents created in the lake kept the light clay-sized deposits in suspension, thus causing an upward grading into coarser sized particles. As the lake continued to drain, the water started flowing as streams which probably meandered over the surface until they incised into channels. This meandering and downcutting formed stream terraces along the course of the river.

While the ice sheet covered the area, its tremendous weight caused the earth's crust to compress downward. Sometime after the ice had melted and Lake Hitchcock had drained, the earth's crust responded to the removal of the ice mass by raising upward (crustal rebound). Since there had been a greater weight of ice in the northern areas, the rebound was greater in these areas. This gives then the effect of tilting of the lake deposits. This has been calculated to be approximately 4 feet of tilt per mile (Koteff, written communication, 1972).

After the lake had drained, the fine-grained deposits were exposed to wind action. With very little vegetation present, the wind reworked the fine-grained materials, forming dunes 20 or more feet high in some places. These dunes are scattered throughout the area, but well developed examples are located on the west side of the Scantic River in the Broad Brook quadrangle (Colton, 1965b).

EFFECTS OF FINE-GRAINED LAKE-BOTTOM DEPOSITS ON URBANIZATION

Most of the deposits that filled the lake presently remain as relatively flat, low lying landforms, most of which are lake-bottom deposits. Most of these lake-bottom deposits are fine-grained deposits, and aside from the relative flatness inherent with their deposition, they present very few characteristics that are favorable for urbanization. Since these deposits are located in an area that is most likely destined for urbanization, it is apparent that they merit further study.

A primary concern for urbanization is a ready supply of water for domestic and industrial use. The fine-grained lake-bottom deposits are most often quite unsuitable as a source of water supply. Although these deposits are frequently saturated with water, they usually have a very low permeability. As a result, they yield insufficient quantities of water for urban needs. Conversely, if these materials do not readily transmit water, they also do not readily accept water. This then renders them equally unsuitable as a material for leaching fields for septic or sewage treatment facilities. Poor permeability also affects the flow of streams originating in areas underlain by these materials. During heavy rainfall or snowmelt, this ground is incapable of accepting large quantities of water. This results in the creation of large volumes of runoff and potential flooding. It also presents problems in surface drainage in flat areas where the water often collects in shallow depressions, creating wet, muddy conditions. During prolonged dry spells, these materials yield only very small quantities of groundwater to the streams.

This then results in very low streamflow, thus limiting the usefulness of the stream as a water supply or as a medium for waste transportation or dilution of transported waste.

Lake deposits may contain local lenses of sand and gravel. If these coarse-grained deposits have a source of recharge such as a till-clay contact, or if they are in a bed that is continuous to the surface, they may serve as a local supply of water. This is seldom the case, however, and most of the deposits are poor sources of water for urban uses. Fortunately, as stated earlier, the Hartford area is underlain by sedimentary rocks which can be tapped as a source of water, thus overcoming the water problem in this area. Quite clearly this deep source of water from bedrock presents at least one problem; increased cost.

It should be pointed out at this time that the low permeability that makes the fine-grained lake-bottom deposits of limited value as a water source, may in the future have a very valuable use. Since the fine-grained materials act as a barrier to water movement, they can be used as a container for waste materials; either as a protective barrier to prevent downward migration of leachate in a sanitary landfill site, or possibly as underground sites for waste injection such as in coarse-grained deposits isolated within the clay. There are of course many other factors that must be considered before either of these two types of operations are planned. Still, the potential for this operation exists.

Another problem that fine-grained lake-bottom deposits present to urbanization is that these materials, when saturated, often behave as liquids or plastics when under compression or tension. This presents engineering problems in construction of large structures. "Floating" foundations, pilings, or other engineering methods can usually overcome these unfavorable conditions, but most often there is an increase in cost.

As described earlier, the lake-bottom deposits may occur as varved deposits or they may have local lenses of sand and gravel. There is another type of lake-bottom deposit found in this area that may be beneficial to urbanization. In certain areas of Lake Hitchcock which were relatively distant from the areas where waters were being discharged into it, and where there were extremely quiet water conditions, thick massive layers of relatively pure clay were deposited. Some of these clay deposits have been developed in this area for use in brick manufacturing. Many of these brick facilities have since ceased operation; however the clays still remain as a very important resource should the demand be renewed.

It is apparent that the lake-bottom deposits play an important role in the <u>planned</u> development of Connecticut. I stressed the word planned, since with man's current technological ability, most any haphazard development could be made to work, provided man is willing to pay the price. For example, assume a developer builds a housing complex on a flat area where a thin layer of sand overlies a thick sequence of fine-grained lake-bottom deposits. Everything might work out well at first, but as time passes, problems might arise. For instance, the thin sand layer might not be able to adequately handle the amount of sewage discharge created by the complex. There may be differential settling of the foundations, thus causing structural problems in the buildings. Or suppose there was an increase in demand for clay of brick-making quality. The deposits in this area might have been of good enough quality to have been developed, but now they are inaccesible. Clearly all potential resources cannot be protected from development. A more critical look should have been given to the area prior to development. This then may have given some useful information on the quality and quantity of the deposit, thus making it more possible to plan for the future.

One step to assist in the planned development of Connecticut is to map the extent of the fine-grained lake-bottom deposits. Almost the entire area has already been mapped by geologists who made surficial geologic quadrangle maps. Also, many well drillers have contributed subsurface information to the Water Resources Division of the U.S. Geological Survey in Hartford. With this information available, plus other published and unpublished information, it is possible to map the lake-bottom deposits. The project to map the lake-bottom deposits was a lengthy process involving feasibility studies, collection of additional data, interpretation of geological processes, and the conversion of existing technical maps into new maps showing the detailed distribution of the fine-grained lake-bottom deposits. This mapping procedure is discussed at length in the section that follows.

PART II

TEST MAPS - HARTFORD NORTH QUADRANGLE

It would be prohibitively expensive to map the principal clay deposit [3] in a program involving specific field mapping and an extensive drilling program. As a result, the first step was to determine if maps of the principal clay deposit could be made by utilizing existing data. In order to determine this, the Hartford North quadrangle was chosen as a test area. This area was selected mainly because there was an extremely large amount of information available for use. The surficial geology of the area had been mapped by R.V. Cushman in 1963, a bedrock contour map had been prepared by Robert B. Ryder in 1972, and a large amount of test drilling had been done in the area, with many of the drilling records on file at the Water Resources Division office at Hartford. This information was supplemented by additional information obtained by C.T. Hildreth, from various municipal engineers and from the State Highway Department.

The subsurface information consisted of logs of varied detail and accuracy, and from many different sources. Some of these logs

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3) The term "principal clay deposit" refers to the fine-grained lake-bottom deposits, and for the purpose of this report, the two terms will be used interchangeably. Other fine-grained deposits not associated with glacial Lake Hitchcock are not mapped. In this area, these deposits are primarily deposits of flood plain alluvium, although a few minor deposits of lake-bottom sediments not associated with Lake Hitchcock have also been omitted from the map.

were extremely detailed, giving a very accurate account of the materials sampled during the drilling process, while other logs gave very sketchy accounts of the drilling record. These logs had to be studied very carefully, selecting only those logs that were of a quality that was useful in the preparation of the maps.

All useful well locations were plotted on a 1:24000 scale base map. A number of trial cross-sections were then drawn in order to determine a suitable scatter of points at this scale. It was determined that in order to map using only test hole and well data, a spread of one data point every 2000 feet was good spacing. Much closer spacing usually added little or no control, whereas much wider spacing created a lack of essential control. By utilizing other information in the areas where there was a lack of subsurface data, it was possible to map the area without greatly reducing accuracy. Much of this additional information was obtained from the bedrock contour map of Ryder. By estimating a till thickness from nearby subsurface information, and adding this value to the altitude determined from the bedrock contour map, an approximate altitude of the lower surface of the principal clay deposit was determined. The control on the upper surface of the principal clay deposit was much greater. Many shallow well or test holes, especially those from sewer and water line excavations, only penetrated the upper surface of the deposit. These holes provided control for the upper surface of the deposit while also giving a minimum thickness of the deposit at that location. Similarily, holes that did not even reach the deposit still provided a minimum thickness of the material overlying the principal clay deposit.

After sufficient data was collected, a contour map of the upper surface of the principal clay deposit was prepared. The thickness of the principal clay deposit was then determined by interpolating between this surface and the lower surface of the deposit, which was either read directly from well or test hole information, or was estimated from the bedrock contour map. The thickness of the material overlying the principal clay deposit was also determined by interpolating between this map and a topographic contour map, and was checked with the well and test hole information.

The maps prepared in this manner present a fairly accurate picture of the principal clay deposit. One obvious lack in control is the boundaries marking the horizontal limits of the clay deposit. Since this contact is exposed in much of the quadrangle, this information was obtained from the surficial quadrangle map of the area, thereby eliminating the field work that would have been required in order to accurately map the limits of the deposit (Cushman, 1963).

CONSTRUCTION OF CLAY MAPS

After analyzing the techniques and results obtained in preparing these maps, it was determined that other maps of this type could be prepared utilizing only the existing information currently on file in the U.S. Geological Survey offices. A working bedrock contour map being prepared by Robert B. Ryder exists for the entire area of study (at a scale of 1:48000), and surficial quadrangle maps have been published for all the quadrangles in the area (Colton, 1960, 1965a, 1965b; Deane, 1967) except the Glastonbury quadrangle. This quadrangle has unpublished surface materials information available in the form of field maps (textural) prepared by Deane, Thompson, and Richert.

One decision that had to be made before preparing the maps was the accuracy to be reflected on the maps. The accuracy was defined mainly by the spacing of the data points combined with the other information used in compiling the maps. This accuracy could have been reflected in at least two ways. One method would have been to map the area using the smallest possible contour interval throughout the area. Then, in areas where this contour was poorly controlled, it could have been noted either directly on the map by using special line symbols, or on a separate map in the form of a reliability map. A second method - the one chosen for these maps - was to select a contour interval large enough to accurately present the least controlled areas. This method was chosen in order to present the map in a form that can most easily be used by the people who will use it. Since the maps are intended to be used for planning purposes, it was determined that a generalized contour interval was most useful. Also, these maps were never intended to be used for site evaluation; therefore eliminating the need for specific detailed information.

In some areas the mapping of the principal clay deposit only involved the direct transfer of information from an already existing map to the new clay-map form. The mapping of the distribution of the principal clay deposit in the northern part of the Windsor Locks quadrangle was of this type, since most of the clay deposits are exposed at or near the surface. The thickness of the deposit was determined from subsurface data and from interpolation with the bedrock contour map.

The mapping of the principal clay deposit followed much the same procedure in the Hartford South quadrangle. Deane indicated all the areas of the quadrangle that were underlain by Lake Hitchcock clays,[4] so the mapping again only involved the transfer of contacts to the working maps. The thickness of the deposit in this area was determined from subsurface information, the bedrock contour map, and from a number of cross sections prepared by Deane. The thickness of material overlying the deposit was determined from the sections and from subsurface information.

A number of procedures were followed in mapping the rest of the area in Connecticut underlain by the principal clay deposit. These procedures are discussed in the following section of this part of the report; however, the order that they are presented is not necessarily the order used to prepare the maps. Instead, many of the procedures were used together, thus acting to reinforce or point out errors

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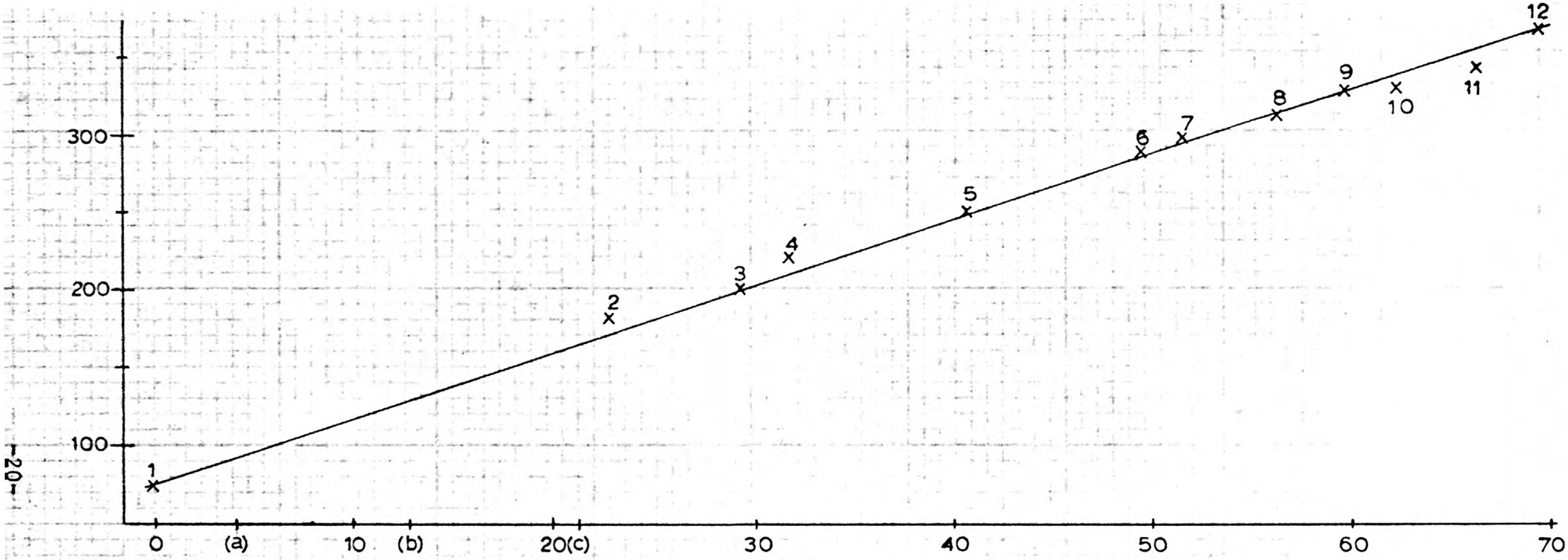
4) Some areas in this quadrangle are underlain by a clay body deposited prior to the existence of glacial Lake Hitchcock. These deposits are not mapped, since they are not directly related to the Lake Hitchcock deposit, and since they occupy relatively little area compared to the Lake Hitchcock deposits.

in the mapping process.

SPECIAL PROCEDURES IN CONSTRUCTION OF CLAY MAPS

One of the first steps taken to map most of the areas of the deposit outside of the Hartford North quadrangle, was to determine the limits of Lake Hitchcock. The limits of the lake quite frequently approximate the limits of the principal clay deposit, and are at least a maximum limit of the deposit. Thus, if the extent of the lake can be mapped, the maximum extent of the principal clay deposit will also be mapped. By determining the altitude of the lake surface, it might be assumed that this was the altitude of the lake at all locations. This, however, is not the case, since crustal rebound that took place after the draining of the lake has complicated the problem. This rebound elevated the northern areas of the lake more than the southern areas, and as a result, the lake deposits appear to tilt downward to the south. Therefore, in order to reconstruct the lake levels, it was necessary to consider the amount of crustal rebound that took place.

A graph has been constructed by Koteff (written communication, 1972) which can be used to approximate the levels of Lake Hitchcock. This graph (fig. 1) was constructed from lake levels determined from field observations by Koteff, and from information obtained from Jahns and Willard (1942).



Vertical scale — feet above mean sea level
Horizontal scale — miles from New Britain spillway
(a) latitude 41°45' (b) latitude 41°52' 30" (c) latitude 42°00"

Figure 1. Altitude of Lake Hitchcock water plane (Koteff, written communication, 1972) - altitude inferred from field data on contact of deltaic topset-foreset beds (Koteff) and from information from Jahns and Willard, 1942.

Point	Location	Altitude
1	New Britain spillway	75±
2	Springfield South delta	185±
3	Chicopee River delta	200
4	Willamansett pt.(Jahns and Willard, 1942)	220 (five ft. or so too high)
5	Pearl City Plain	247
6	Factory Hollow Plain	287
7	Long Plain delta	295
8	Stillwater Plain	312
9	Montague Plain	324
10	Northward extension Montague Plain	326
11	Barton Plain	345
12	Bennells Brook Plain	365

Altitudes taken from this graph were used to determine the level of Lake Hitchcock at any location, thus making it possible to map the extent of the lake and the associated lake deposits. These altitudes were plotted on the bedrock contour map, with an approximate thickness of till added into the calculations, and the boundaries of the lake were approximately located. The boundaries of the principal clay deposit were assumed to coincide with this boundary unless subsurface or other information indicated otherwise.

This procedure was used to determine the limits of the lake deposits in many areas where the actual contact was buried under other material. However, the procedure usually involved more than just adding a till thickness to the bedrock contour map to determine the contact. Much of the eastern side of the valley is covered with a variable thickness of sands and gravels. The thickness of the sand and gravel was determined from subsurface information and was also added into the calculations. Using this information, plus all available subsurface and other information, it was possible to map much of the eastern limit of the principal clay deposit.

The lake levels served another purpose in the construction of the maps. Since the lake-bottom deposits were laid down under water, there should be no places in Lake Hitchcock where the upper surface of the principal clay deposit can be higher than the lake level at that location. There can be some locations where lake-bottom sediments are at an altitude higher than the level of the Lake Hitchcock water plane, although their extent was not great enough to include them as part of the principal clay deposit. These deposits were formed in lakes other than Lake Hitchcock, and probably existed at or before the time of Lake Hitchcock. At the time these lakes were in existence, the ice had to be sufficiently thick to supply a source of water and sediment to the higher altitude. These lakes may have formed in an elevated valley with its drainage being dammed either by ice or drift, or they may also have formed along the margins of the ice and the side walls of valleys.

There are a number of areas within the lake that are not underlain with fine-grained lake-bottom deposits that were at one time under the lake waters. [5] Two of these areas are located along the Connecticut River. They were probably covered with fine-grained lake-bottom deposits at one time, but the deposits have since been removed by the erosion of the Connecticut River. The Scantic River and Beamans Brook have also removed the principal clay deposit along parts of their courses. The Connecticut River, and other large rivers in the area, have removed part of the total thickness of the principal clay deposit in other areas; however the deposit is of sufficient thickness that the entire deposit has not been removed.

Most of the principal clay deposit located east of the Connecticut River is covered with stream terrace deposits (and also with

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5) There may be other local areas within the limit of the principal clay deposit where the fine-grained lake-bottom deposits are not present, but the distribution of the well and test hole data did not locate these areas.

wind-blown sand in some areas). The surface of the clay deposit was fairly easy to predict in these areas since it is fairly flat in an east-west direction (its altitudes vary within the contour interval used for mapping). Also the surface of the clay deposit slopes at approximately the same angle as the lake surface in a north-south direction (fig. 2). One problem in this area was that the clay deposit gradually grades upward into coarser-sized particles which made it difficult to determine an exact boundary between the principal clay deposit and the stream terrace deposits. Most of the lower surface of the deposit in this area was determined from the well and test hole information and with the bedrock contour map.

DELTAIC FEATURE

The area from the Farmington River delta eastward to the eastern limit of Lake Hitchcock was one area that presented interesting problems in the mapping of the principal clay deposit. There were insufficient subsurface data points in this area to accurately control map units. There were, however, sufficient data to form an interpretation of the glacial deposits in the area. One possible interpretation (not necessarily supported by data available) is that the Farmington River mouth was blocked from the lake for some time after the ice front had retreated from this area. Fine-grained lake-bottom deposits would then be deposited in this area of Lake Hitchcock, directly east of the Farmington River mouth. Later, when the river was opened to the lake, a delta would have started to form. This delta would be

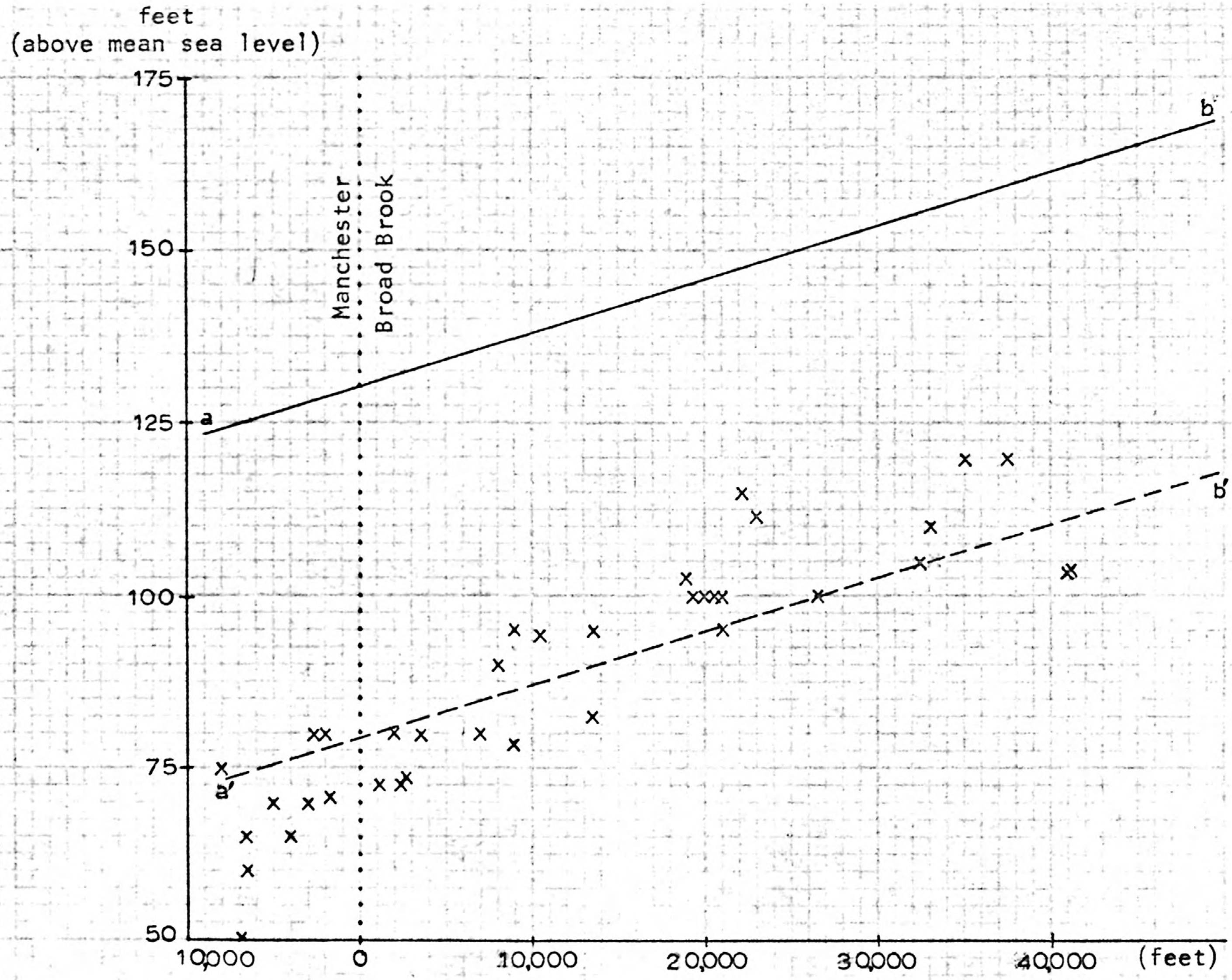


Figure 2. Altitude of upper surface of principal clay deposit beneath stream terrace deposits — Line a - b is inferred altitude of Lake Hitchcock water plane (fig. 1). Line a' - b' is line a - b projected to approximate the upper surface of the principal clay deposit. Data points (x) indicate altitude of top of principal clay deposit. Horizontal distances measured north or south from Manchester-Broad Brook quadrangle boundary.

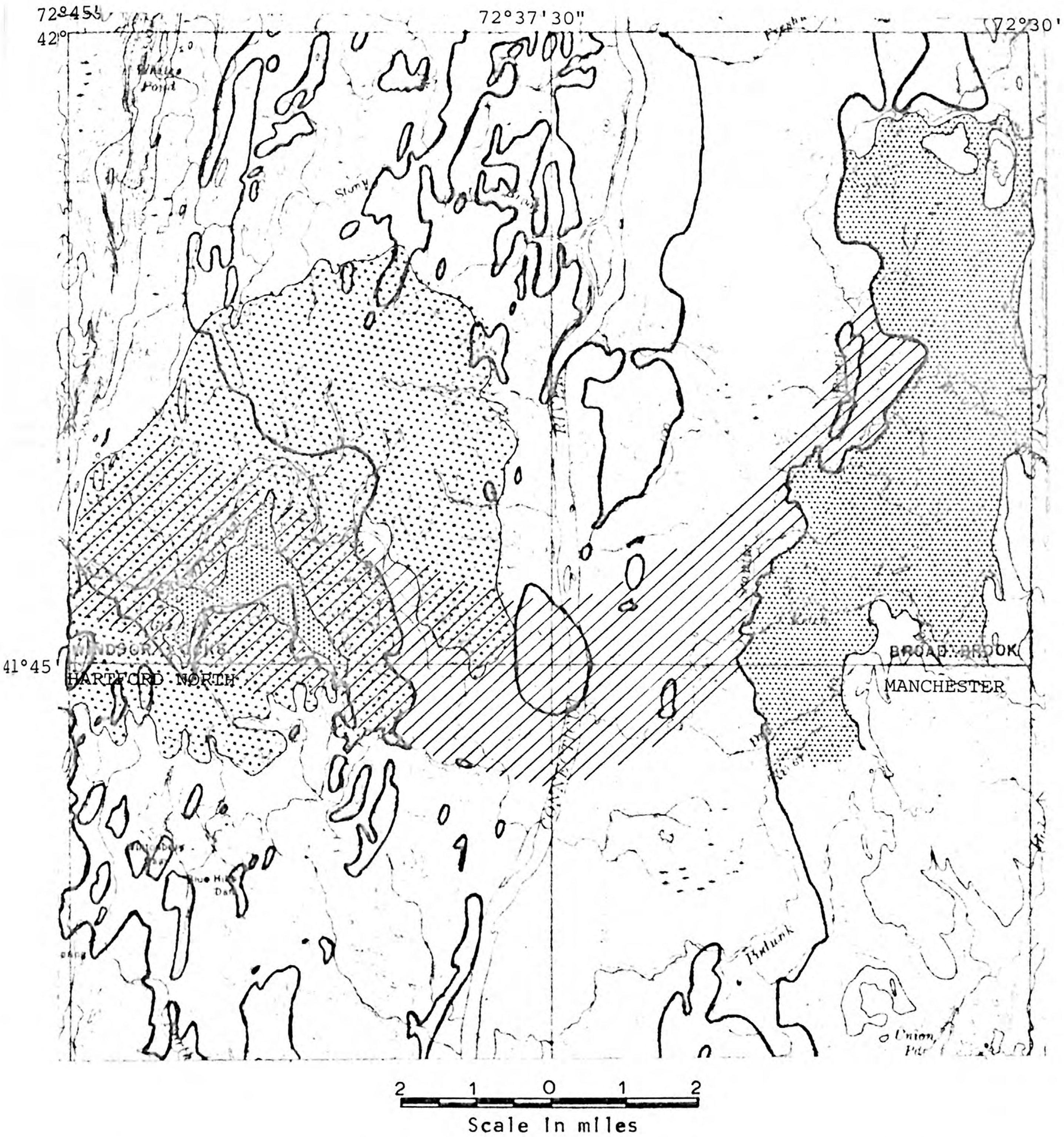
deposited over the lake-bottom deposits. If this were the case, the deposits should be traceable under the entire delta, and the surface of the lake-bottom deposits should be relatively flat, or possibly have a slight depression due to the increased weight of the deltaic deposits overlying them.

A second interpretation is that the main ice tongue blocked the mouth of the Farmington River from Lake Hitchcock, thus preventing the discharge of water into the lake. Shortly after the ice retreated past the mouth of the Farmington River, water started to drain into the lake, and sediments began to be deposited near the mouth of the river. In this case the delta would have been deposited directly on the till (or rock) at the bottom of the lake, since the fine-grained deposits wouldn't have already been present. Then, as the delta spread outward, it was deposited over a thin layer of fine-grained deposits, covering increasing thicknesses of fine-grained deposits as it continued to grow outward. If this interpretation is correct, the lower surface of the delta would be inclined upward, not flat as in the previous interpretation. The deltaic deposits would be thinner at the edge and thickest near the source, while overlying increasing thicknesses of fine-grained lake-bottom deposits as the distance from the source increased. The relatively few logs in this area could support either theory, since any log could represent a local deposit rather than the entire delta. However, the second theory has been selected since a larger regional analysis (discussed in the following section) supports this theory.

ICE FRONT FEATURE

Colton has mapped deposits of ice-contact stratified drift near the source of the Farmington River Delta (Colton, 1960). He has also mapped ice-contact deposits directly across the lake on its eastern edge (Colton, 1965a, 1965b). The surface exposure of these deposits form the sides of a lobate deposit extending southward into the area of Lake Hitchcock. This shape reflects the shape of the ice front that extended into the lake. By studying subsurface data, it was possible to trace these sands and gravels across the lake to complete the U-shaped front of the ice. Figure 3 is a map roughly locating the position of this feature within the Lake Hitchcock area.

This feature indicates that the ice was stagnant in front and marginal to the active ice. Before the ice front reached this position, it dammed the mouth of the Farmington River (as described in the preceding section). The water issuing from the glacier in the area of the Farmington River, drained southward through the Quinnipiac River (Simpson, 1959). On the eastern side of the lake, the ice front blocked the mouth of Broad Brook. Instead, meltwater from this side of the valley probably drained through the Hockanum River into Lake Hitchcock. This is supported by the fact that the altitude of the divide between Broad Brook and the Hockanum River is lower than the topography in the area where Broad Brook would have been dammed. As a result, the water level would be of sufficient altitude to flow over this divide.



Ice-contact stratified drift deposits (includes local areas of till and outwash deposits)

Farmington River delta deposits (includes local areas of till and ice-contact stratified drift deposits)

approximate location of ice-marginal stagnant zone

Figure 3. Area of ice-marginal stagnant zone. (Distribution of surface materials modified after Cushman, 1963 and Colton, 1960, 1965a, 1965b.)

The ice front continued its retreat until it reached a point just north of the Farmington River. At this point, the ice front temporarily stopped its retreat. It was in a lobate shape with its western margin somewhere north of the mouth of the Farmington River, its eastern margin somewhere north of the mouth of Broad Brook, and its central section extending approximately five miles into the lake. At this time the ice blocking the Farmington River melted, thus allowing the water which previously had flowed through the Quinnipiac to drain into the lake. Similarily, meltwater that had been flowing through the Hockanum River was now able to flow out through Broad Brook into Lake Hitchcock.

Meltwater from the active ice supplied the tremendous quantities of silt, sand, and gravel that were required to construct the ice contact deposit across the front of the ice. As the rivers discharged into the lake, they lost their competence, and deposited the heavier materials along the front of the ice. The till hills to the south of the mouth of Broad Brook prevented the waters from flowing southward into the lake. Instead, they were confined between the ice front and the till hills, and deposited the heavier materials in these areas, forming the eastern portion of the ice marginal deposit. The finer silts and clay were carried out into the lake where they were deposited as fine-grained lake-bottom deposits.

Some of the heavier sands and gravels being transported by the Farmington River were deposited against the ice, forming the western portion of the U-shaped ice marginal deposit. Some of the lighter sands and silts were carried out further into the lake where they were deposited on the lake floor. These materials started to form the delta, which built out into the lake in a sequence as described in the preceding section. Numerous rivers and streams draining off the ice also carried material from the active ice. As these streams reached the lake, they deposited the heavier materials as part of the ice marginal deposit.

A short time after the Farmington River opened up, the ice front renewed its northward retreat. Had the ice been stagnant for very long, the Farmington River delta would have extended much farther southward. Instead, as the ice melted to the north, it opened up a more favorable channel around the high till areas to the southeast. With its southward course now abandoned, the river flowed northeasterly into the lake, and built the delta out into the lake in that direction. The ice retreat was faster than the speed with which the delta was growing, although isolated blocks were buried by the deposits, and as they melted they formed the collapsed structures located along the western side of the valley. As the delta grew northward, it was deposited over increasing thicknesses of fine-grained materials that had already been deposited in the lake. The delta continued to grow out into the lake until the lake drained, although the most rapid growth of the delta occurred before the ice melted past the channel located between West Suffield and Provin Mountains approximately 10 miles to the north (Colton and Hartshorn, 1971). When the ice retreated past this point, much of the meltwater from the glacier was diverted through this area into Lake Hitchcock.

Broad Brook continued to drain into Lake Hitchcock until the ice retreated past the Scantic River. After the ice passed this point, much of the water was diverted through the Scantic River into the lake. Most of the sedimentation by Broad Brook into Lake Hitchcock probably stopped at this time.

With this geologic interpretation in mind, it was possible to complete the mapping of the principal clay deposit. This mapping process plays an important although indirect role in the planning of an area. It is extremely important that this information be organized by the geologist, and then presented to the planners in a manner that they can effectively utilize.

PART III

NEED FOR SINGLE SUBJECT MAPS

The maps discussed in this report were designed especially for planning purposes. One obvious characteristic of these maps is that they show only one single subject. First, by showing only a single subject, the maps are clear and easy to read and understand. But more importantly, single subject maps are more useful for land-use planning than are technical maps such as bedrock or surficial geologic quadrangle maps. With single subject maps, the planner is capable of selecting only those combinations of subjects he feels is necessary for a particular planning problem. Also, the planner has to perform very little, if any, interpretation of the data reflected on the single subject maps.

DESCRIPTION OF MAPS

Basically, two types of maps were prepared from the existing information; Thickness of the Principal Clay Deposit, and Thickness of Material Overlying the Principal Clay Deposit. Both types of maps have been prepared at a scale of 1:24000 (approximately one inch equals 2,000 feet) on a 7 1/2 minute quadrangle base map. Six maps of each type were prepared for the area in study. Information from these maps was then used to prepare a compilation of the limits of the principal clay deposit at a scale of 1:125000 (approximately one inch equals 2 miles). This smaller scale was prepared to give an overall view of the entire area. The 1:24000 scale maps are more suitable for most planning purposes. Neither of these map scales is designed to be used for site evaluation. They are designed only to assist in planning and to help identify areas that merit further on-site investigation.

The map showing Thickness of the Principal Clay Deposit shows these thicknesses in intervals of 50 feet. A 25 foot interval was added in the Hartford North quadrangle due to more available data in that area. This map also shows the limits of the principal clay deposit, as does the map showing Thickness of Material Overlying the Principal Clay Deposit. Areas of mappable bodies of sand and gravel occurring under the principal clay deposit have not been included as part of this thickness. However, minor occurrences of sand and gravel interbedded within the principal clay deposit have been included as part of the total thickness of the principal clay deposit.

This map points out that much of the area is underlain by fine-grained lake-bottom deposits, and that these deposits are of substantial thickness in some areas. In most areas the thickness contours are smooth flowing lines, which is a reflection of the relative smoothness of the upper and lower surfaces of the principal clay deposit in relation to the contour interval of 50 feet. An area of exception is in the eastern part of the Broad Brook quadrangle, where the contours are quite irregular. This is due to the deep, irregular dissection of the upper surface of the principal clay deposit by the Scantic River.

The map showing Thickness of Material Overlying the Principal Clay Deposit shows only the thickness of naturally occurring material overlying the principal clay deposit. It does not include mappable artificial fill as part of this thickness. For example, the fill material along the highways and dikes is not included as part of the total thickness of material overlying the principal clay deposit. This thickness does include all fine-grained material overlying the principal clay deposit that are not actually lake-bottom deposits. For example, the flood plain alluvium of the Connecticut River, much of which is fine-grained, is included as part of the total thickness.

This map shows the thickness of material overlying the principal clay deposit in intervals of 20 feet. It points out that the principal clay deposit is very near to the surface in much of the area of glacial Lake Hitchcock. (less than 20 feet of material overlying the principal clay deposit). In most areas the thickness contours are quite irregular, which is a reflection of the irregular topographic land surface.

INTRODUCTION TO MAP USAGE

When using these maps for planning purposes, the planners must make certain basic decisions such as allocation of funds, priorities of land-uses, etc. They must also follow all legal restrictions placed on land-use. Certain decisions have been made in this report in order to illustrate the uses of the maps. These decisions may vary from place to place due to different priorities or regulations, and they may change with time due to technological advancement. Therefore, they are not meant to be guidelines for planning. Instead, they are only used as an example to show various ways that these maps can be utilized. Also, these examples should not be considered to be complete guides for planning, since these two maps show only a small portion of the total information needed for the effective planning of an area.

LOCATION OF FAVORABLE SITES

These maps can be used to assist in locating potentially favorable sites for various land uses. This example concerns locating a sanitary landfill site. It has been decided (for this example) that one favorable condition would be to locate the landfill in an area where there is a thin layer of material overlying a relatively impervious layer of material. This would supply a thin layer of workable material to be used as cover for the landfill, and an impervious layer below the landfill to prevent downward migration of leachate. The area on the map showing less than 20 feet of material overlying the principal clay deposit at least partially fills this requirement. These areas can then be studied with other factors in mind.

LOCATION OF PROBLEM AREAS

These maps can be used to assist in locating potential problem areas for various land uses. This example concerns locating housing areas, and to determine building regulations for those areas. It has been decided (for this example) that part of the area having less than 20 feet of material overlying the principal clay deposit may by susceptible to problems such as poor septic systems, poor drainage, and differential settling of foundations, if used for housing areas. Since these exact locations cannot be determined from the maps, it is decided that before any housing developments can be approved in these areas, evidence from on-site investigations (such as percolation tests, test borings, soils surveys, etc.) would have to be provided showing that these specific problems will not be encountered, or that they can be overcome if they do exist.

IDENTIFICATION OF PROBLEMS

If a person is interested in utilizing a piece of land for a specific purpose, he can obtain information from these maps. Although the maps shouldn't be used for site evaluation, they can be used to determine the type of conditions that may occur in an area. For example, if the map shows near-surface clay in the area concerned, it can be expected that poor drainage, septic problems, and foundation problems may occur. Then, the site can be evaluated with this knowledge in mind. The problems may or may not exist, but at least the person knows what to look for.

COST ESTIMATION

These maps should not be used for site evaluation; however, they can be used as an aid to cost estimation. Any construction concerned with problems encountered in building over clay can use these maps to aid in planning. Although construction costs in clay areas vary according to the properties of the clay, information can be used from these maps to assist in estimating these costs. For example, it may be determined that there is probably enough material overlying the clay to build "floating" foundations. The cost of a drilling program to test this possibility can be estimated from the depths shown on the maps.

COMBINATION OF MAPS

Instead of using these two maps alone, they usually are more effective if they are used together. This example concerns locating a potential source of clay. It is decided (for this example) that at least 50 feet of clay are needed, and that the deposit is within 20 feet of the surface in order for the source to be economically productive. These two depth ranges can be taken from the maps and plotted together, to determine areas that merit further investigation. Tests would still have to be made to determine if the clay was of sufficient quality and quantity to be used, but many non-productive areas have already been eliminated.

To obtain maximum effectiveness, these maps may also be used in conjunction with other maps showing surface materials, depth to bedrock, depth to water table, flood prone areas, and other land-resource information. These types of maps are not readily available for most of this area at present, but they are currently being prepared and published by the Connecticut Valley Urban Pilot Project - a project of the United States Geological Survey.

The descriptions in this part of the report are only hypothetical examples of how these maps may be used in planning. In actual land-use planning, entirely different parameters may be considered. Still, these examples illustrate various approaches that can be used in order to plan the development of a rapidly growing area such as the Connecticut Valley lowlands.

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