Connecticut Terroir

A geology and wine-tasting fieldtrip sponsored by the

Geological Society of Connecticut

Terroir… **the particular effect bestowed upon the wine by the geography, geology, and local climate of a vineyard region; from the French "terre" meaning earth, land, soil**

Fieldtrip Guidebook No. 3

Geological Society of Connecticut

ThirdAnnual Fieldtrip

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Part 1. Eastern Connecticut Vineyards

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Connecticut Terroir

Terroir comes from the French word *terre* meaning earth, land, soil. The concept of terroir was developed in France by winemakers observing the differences in wines from different regions, vineyards, or even different sections of the same vineyard. The French crystallized the concept as a way of describing the unique aspects of a place that influence and shape the wine made from the grapes grown there. Much earlier, the winemaking regions of the ancient world had already developed a concept that different regions had the potential to create very different and distinct wines, even from the same grapes. The ancient Greeks stamped amphorae with the seal of the region they came from and different regions established reputations based on the quality of their wines.

Despite our cool climate, grapes grow well in Connecticut. When Pilgrims landed in New England in 1621, they reported “Here are Grapes white and red, and very sweete and strong.” In 1639, the Saybrook settlement took George Fenwick’s grapevine seal as its own, and in 1644 it became the seal of the larger Connecticut colony (Lehman and Nawrocki, 2011); today the Connecticut State flag displays 3 grapevines and the motto “Qui Transtulit Sustinet”-- roughly translated “he who is transplanted still sustains” and relates to the planting (or transplanting) of grapevines. The purpose of this fieldtrip is to examine the local geology and soil characteristics along the “Connecticut Wine Trail” in eastern Connecticut and to determine what effects, if any, that particular terroir has upon the local wines.

In 2012, Connecticut has 31 operating wineries and vineyards spread across the State and located in all geologic terranes-- six in proto-North America (including two in marble valleys), seven in western Iapetos, three in the Newark Basin, two in Bronson Hill, six in eastern Iapetos, and seven in Avalon (fig. 1).

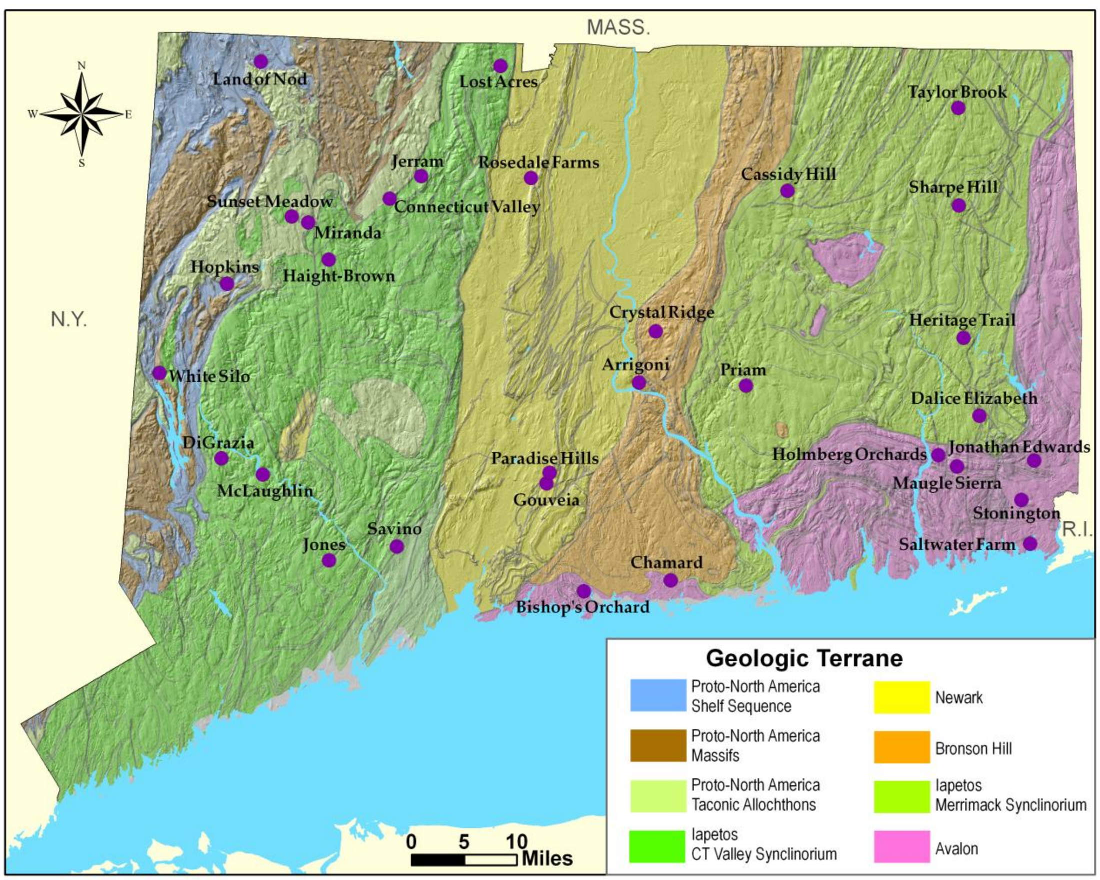


Figure 1. Geologic terranes (modified from Rodgers, 1985) and locations of vineyards and wineries in Connecticut.

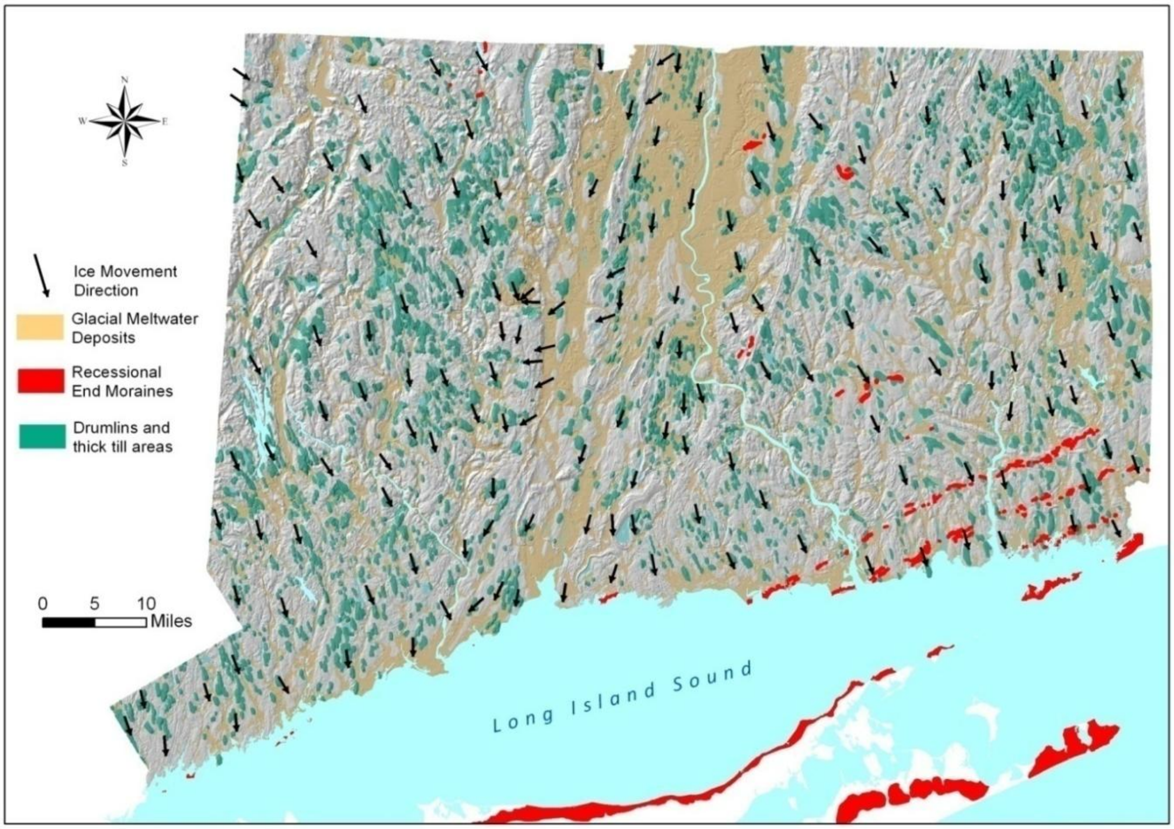


Figure 2. Ice-movement directions, distribution of drumlins and other thick till areas, recessional moraines, and glacial meltwater deposits in Connecticut (modified from Stone and others, 2005

Bedrock beneath Connecticut consists of Precambrian and Paleozoic metasedimentary and metaigneous rocks (gneiss, schist, granitic gneiss, marble, and pegmatite) in the eastern and western highlands, and early Mesozoic arkosic sedimentary rocks (sandstone, siltstone, conglomerate, and shale), locally intercalated with igneous basalt and diabase in the central lowland. The lithology and structure of these diverse rock types control the larger aspects of Connecticut's landscapes—highlands versus lowlands, and positions of majors ridges, valleys, and basins. Finer details of our landscape such as streamlined hills, drumlin hills, morainal ridges, valley fills of glacial meltwater deposits, and lake-bottom plains were developed during the advance and retreat of at least two continental ice sheets during the Quaternary. Although a small state, Connecticut has a plethora of different landscapes (terroirs) due to the complexity of its bedrock, glacial, and postglacial geology. Connecticut geology has also influenced the development of different soil types and microclimates. Some vineyards are located near Long Island Sound (a geologic feature itself) and enjoy the warmth and moisturizing effects of the coastal climate; others are far from the sea in the northeastern and northwestern hills.

The character of glacial deposits in Connecticut is in large part determined by the physical characteristics and mineral composition of the source rocks. This is true not only in areas directly underlain by specific rocks, but also "down-ice" in the direction that the glacier moved. The directions of movement (shown by the arrows on figure 2) were south-southeast in most of Connecticut, but southwest to nearly west on the western side of the major ice lobe that developed during ice retreat in the central lowland (Hartford Basin). Abundant fragments of a particular rock generally occur within a few miles downstream from its source area, but scattered fragments, particularly of hard rocks, may occur tens of miles away. In the Glastonbury area of central Connecticut, red till derived from Jurassic sedimentary rocks was deposited up to a mile southeast of the Mesozoic eastern border fault and is commonly found overlying gray metamorphic rocks in the nearby uplands (Langer,1977).

Many Connecticut vineyards are located on thick glacial till deposits, including seven of them which are on drumlins, like Sharpe Hill, Gouveia, and Hopkins; these vineyards are situated high in the landscape on hillsides or hilltops. Other vineyards, like Maugle Sierra, Jones, and Rosedale Farms are located in valleys on glacial meltwater deposits, and the grain-size of these deposits varies greatly from coarse cobble gravel (as at Maugle Sierra) to fine sand (as at Jones).

Connecticut Soils

The largest percentage of Connecticut's soils developed on bedrock controlled ablation or "meltout" till landscapes. These soils generally have sandy loam textures, underlain by sandier material in some cases, and range from somewhat excessively to very poorly drained. Stoniness, shallow depth to bedrock, and slope are the most common limitations for agriculture.

The second largest acreage in Connecticut is in basal (or lodgment) till, material with a compact hardpan within a few feet of the surface. These soils range in texture from sandy loams to silt loams, depending on their lithology, and from well to very poorly drained. The hardpan can be a mixed blessing for agricultural production, as perched water can cause poor drainage, but also holds moisture in the soil during dry periods.

Glaciofluvial (outwash) soils are the next most extensive. Surface textures range from silt loams to loamy sands, which are underlain by sands and gravels. Drainage class ranges from excessively to very poorly drained, but many outwash soils are droughty. Available water capacity is influenced by the depth and texture of the loamy surface. Fertility (cation exchange capacity) is also lower in these soils than in the tills.

Smaller acreages of soil in Connecticut include glaciolacustrine soils, which are found mainly in the Connecticut River Valley. They have silty and clayey textures for the most part and many are poorly and very poorly drained. Alluvial soils are good agricultural soils in terms of fertility and water holding capacity, but are subject to flooding. Organic soils are found in wetlands. Most vineyards in Connecticut are located on glacial till and outwash soils. Grapes prefer to be in soils that are moderately well drained or better.

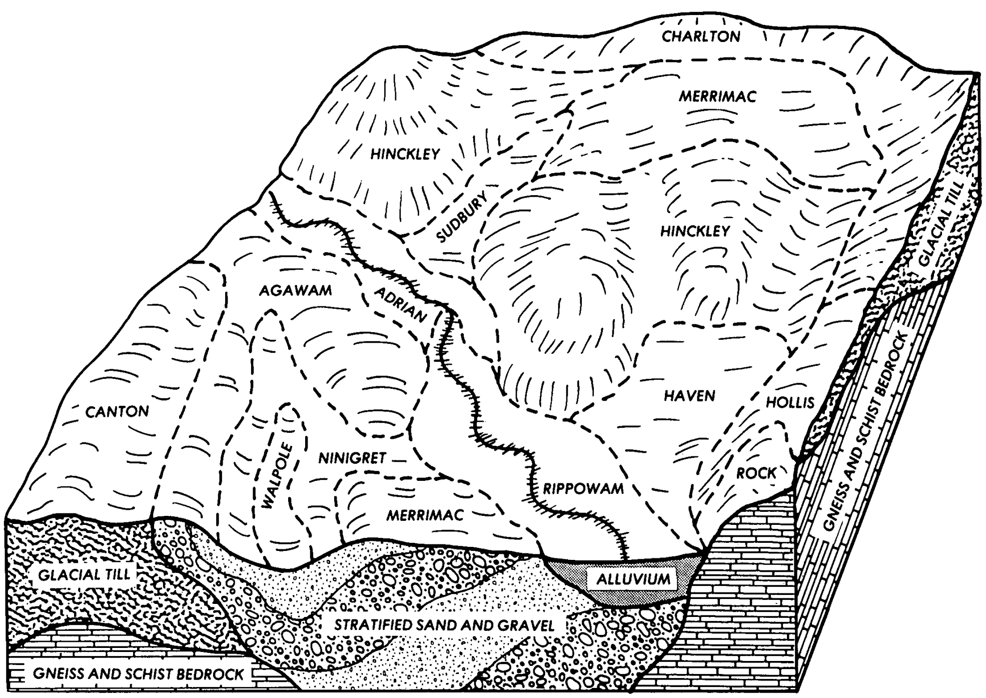


Figure 3. Block diagram **showing the relationships between soils, landscapes, geology, and parent material (modified from Soil Catenas of Connecticut, CT Department of Environmental Protection and USDA, Natural Resources Conservation Service, 2006)**

A few remarks about Grapes, Wine, and Geology: by Howard Bursen

The very fragmentary remarks that follow are based on 35 years' experience growing grapes in New York and Connecticut.

There are 3 major factors determining whether a particular vineyard site is capable of producing fine wine grapes. They are **grape variety**, **climate** and the **site geology**. Here we are interested mainly in the third factor, but a brief mention of the first two is in order.

1. Grape variety (or *cultivar*): Clearly, the vineyard cannot produce quality wines unless it is planted to quality wine varieties. There are thousands of good wine cultivars from all over the world.
2. Climate: The climate must be suitable for grape growing. Connecticut's harsh winters and short frost-free season greatly limits the varieties that will thrive and ripen here. Fortunately, this includes some of the world's finest wine varieties, such as Chardonnay, Riesling and Cabernet Franc.

Assuming we have chosen a reasonable site and suitable varieties, how does geology affect the vineyard's product?

Physical factors:

Drainage

Grapevines do not thrive in waterlogged soils. "The vine does not like wet feet". In our humid climate, heavy clay soils and soils with shallow water tables should be avoided. So too, "hardpan" soils with a "perched" water table are problematic. The water excludes air, and the oxygen-starved roots won't thrive.

Topography

A hillside can help alleviate drainage problems, by shedding some of the excess water. But it's only a partial compensation for a heavy soil. However, the topography strongly affects the vineyard by modifying the site's own local climate. Here is an example. On a clear windless night, infrared radiation escapes into the sky. The coldest (therefore densest) air sinks and collects in topographic lows. The result: A valley or hollow may well get a late Spring frost, nipping the shoots. In contrast, the coldest air runs off the hillside almost like a liquid. Hillsides often escape those Spring frost events. The same is true of early Fall frosts. And the same is true for Winter cold snaps; A valley bottom might experience -20˚F (devastated vines) while the hillside vines see only a moderate -10˚F (chastened but viable Chardonnay).

Soil Chemistry

Soil pH:

I write with some trepidation here, because this group is far more knowledgeable about soil chemistry than I.

Soil pH is partly a function of the underlying bedrock. Many eastern Connecticut soils are quite acid, with pHs in the low 5s. This is, I believe, partly due to the gneisses and schists on which these soils developed. Contrast this with the situation in northwestern Connecticut, where some valleys are underlain by limestone or marble.

The significance for winegrowing is that low pH soils bind some critical plant nutrients, making them unavailable. This often shows up as leaf symptoms of various deficiencies. Available Potassium, for example is often low, and must be supplemented. Many vineyard sites would benefit from large applications of lime – occasionally up to 7 tons per acre. The target pH is around 6.5 to 7.0 depending on grape varieties. We normally use dolomitic limestone. If large rates of "high calcium limestone" (meaning true limestone) are used, it can cause magnesium deficiency, as the excess calcium prevents uptake of magnesium. It's all about balance.

Contrast this low pH situation with California's dry Central Valley. There, low rainfall and high evaporation leads to buildup of basic soils with overly high pH. (Think caliche, think bitter soapy playa deposits.) In Connecticut the rain and snow wash the basic components away. That plus the generally acidic nature of the gneisses and schists, leaves us with low pH soils. Lowest I've seen is an Ellington site with fields testing at pH 4.9. Grapes will definitely grow in such soils, but the vines – and resulting wines, are often unbalanced.

"Terroir"

We finally come to the observation that different vineyard sites within the same region can produce wines with distinctive personalities. This is true for some, but not all sites. Sharpe Hill's Chardonnay has a "flinty" or "mineral" quality not found in Long Island Chardonnays. Baco Noir wines grown on the paleozoic shales of Bully Hill, in New York's Finger Lakes, have an herbaceous or vegetal character which is absent from the same variety grown in Pomfret. Is it something in the soil, a true taste of the local ground? Maybe yes and maybe no. Such questions are hotly debated by winemakers. New Zealand Sauvignon Blanc has a markedly different aroma compared to the same grape grown in the Napa Valley. Is it the result of differences in the soil, or is it the vastly differing climates? Consider how difficult it would be to answer this question: To date there are over 3,000 distinct substances identified in wine. Some are aromatic and are noticeable in extremely low concentrations measured in parts per trillion. Two fermenting barrels of the same Chardonnay and the same yeast strain, will often smell and taste different. No surprise, since the two yeast populations show different profiles as to which sets of genes are being expressed. A truly controlled experiment would be a daunting project indeed. Still, when we notice consistent differences, we are often tempted to attribute them to differences in the soil. But this ignores a host of complexities (climate, topography, cultural practices, etc.)

So is terroir (*gout de terroir)* a real phenomenon? With a broad definition of *terroir*, the answer is assuredly "Yes." And Geology plays a big role in the form of topography, soil structure and soil chemistry. But is there some unique, almost magic ingredient in the soil itself, which makes one vineyard's wine different from a neighboring one?

Let's discuss it over a bottle of wine.

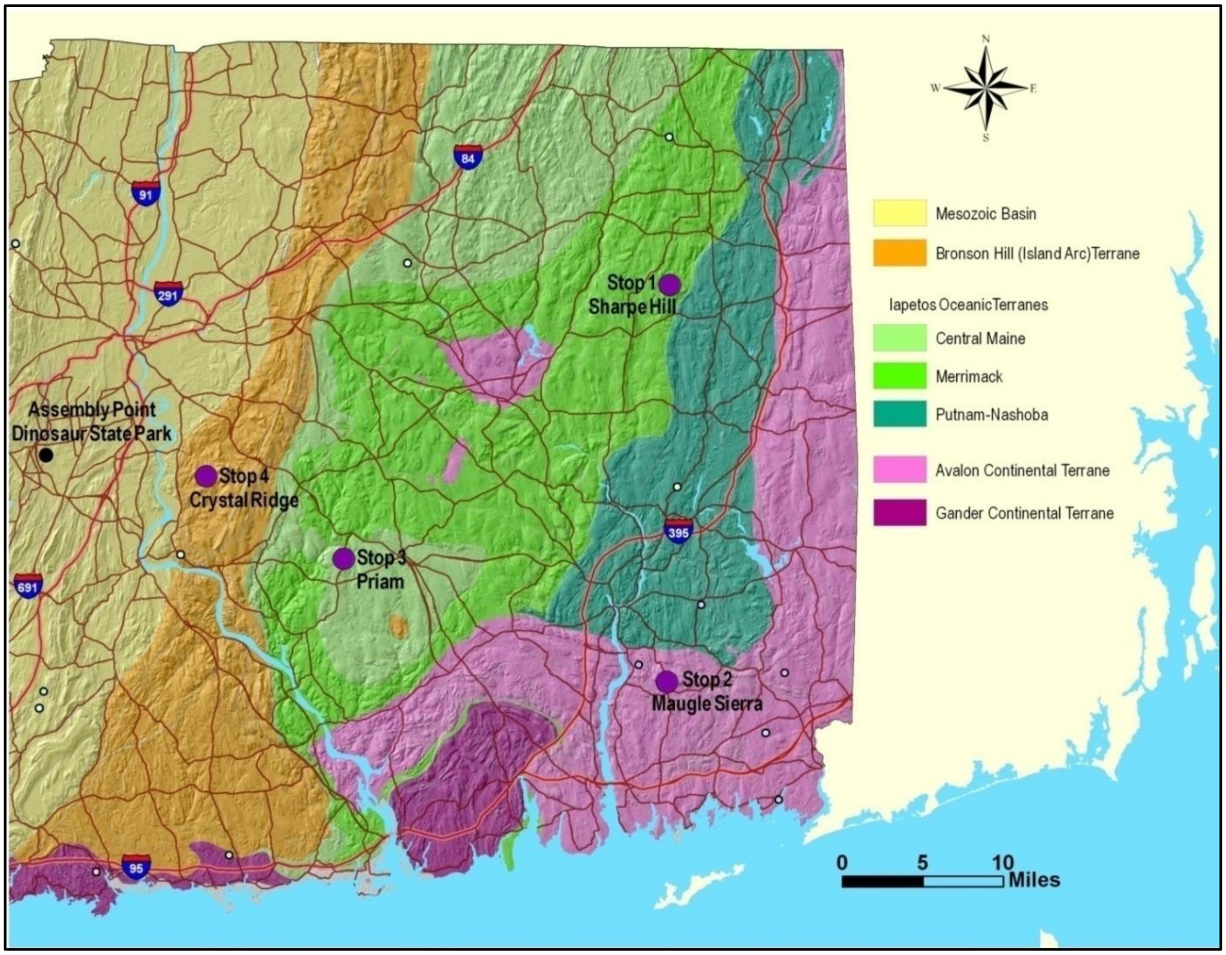


Figure 4. Geologic terranes in eastern Connecticut; all terrane boundaries are thrust faults (modified from Walsh and others, 2007); and locations of field trip STOPS.

Fieldtrip Stops. Part 1-- Eastern Connecticut Vineyards

Assembly Point. Dinosaur State Park, Rocky Hill, Connecticut

0.0 Turn left out of parking lot of Dinosaur State Park onto West Street.

0.1 Rather overgrown outcrop of East Berlin Formation (Jeb) red-beds are on left after employee parking lot. Normal fault (down to north) crosses road just after this outcrop

0.2 Hampton Basalt (Jha) underlies hill on left.

0.5 Outcrops of basalt may be seen on left about 25 yards up Capital Blvd.

0.7 Turn left at third signal onto entrance ramp to I-91N.

1.1 On right the contact of the Hampton Basalt with the underlying East Berlin Formation exposed in highway road cut.

1.5 Outcrops of East Berlin Formation will be passed within the next half mile. Poison ivy and bitter sweet vines mostly cover reddish brown sandstone and siltstone. No gray lake beds are exposed.

2.5 Approximate axis of Rocky Hill anticline

4.0 Floodplain of Connecticut River on right. Every couple of years this area fills with flood waters from regional heavy rain events or spring snow-melt.

7.1 Dike on right protects south Hartford from flooding. A large part of the Connecticut River floodplain in Hartford and East Hartford was built upon years ago. After a spring flood in 1936 (highest flood of record) and the post-hurricane flood in 1938 (second highest of record), dikes were built to protect the flood prone areas.

8.5 Exit on right (Exit 29) to connect to I-84 East.

11.0 Merge with I-84 East. Make your way to right lanes.

12.7 Bear right onto I-384E at exit 59.

18.0 Low overgrown outcrop on right is conglomerate of the Portland Formation (Jp). The Eastern Border Fault of the Mesozoic Hartford Basin is in the ravine just east of this outcrop. Entering Bronson Hill Terrane.

18.5 Glastonbury Gneiss (Ogl) outcrops on both sides of highway. This outcrop is described in detail (Stop 1) in Wintsch and others (2012). Typically, the Glastonbury Gneiss is a granodiorite porphyry with k-feldspar porphyroblasts. Most outcrops show a mineral lineation produced by elongate aggregates of biotite. The rock has magmatic features (~450 Ma origin) with a strong Alleghanian overprint.

19.8 Bolton Schist (Littleton Formation – Dl) on left. This is a gray fine-grained muscovite schist and quartz-muscovite schist. It contains garnet and staurolite in some layers.

21.3 Bolton Notch. Bear right following Rte. 6. Rocks cropping out on west side of Notch are Littleton Schist, Fitch Formation (Scf - which has small caves that can be seen when trees and vines are not covered by leaves) and Clough Quartzite (Sc). Quarry on right produced quartzite dimension stone. Rocks of Middletown Complex crop out on east side of Notch. Then we enter a thin slice of Central Maine Terrane.

22.5 Passing cuts of Southbridge Formation (SOs).

24.0 Hebron Gneiss (SOh). This outcrop is part of the Merrimack Terrane and described in detail (Stop 2) by Wintsch and others, 2012. Boundary between Central Maine Terrane and Merrimack Terrane just west of this outcrop. The Hebron is a fairly widespread formation that we will see (in passing) later in the trip. It is a metamorphosed mudstone and calcareous mudstone that today is calc-silicate gneiss and granofels and schist. It typically is gray and dark gray. In many places is has pods and layers of non-foliated pegmatite, much of which is boudinaged.

24.6 Hebron Gneiss outcrop. Bedrock for next several miles covered by till or sand and gravel deposits.

26.7 Intersection with Rte. 316. Aeromagnetic survey provided data to infer a covered part of the feeder dike system for the Talcott Basalt flow at this location. Dike, referred to as the Higganum Dike extends from East Haven well up into Massachusetts.

30.1 Approximate contact (not exposed) of Hebron Gneiss with Tatnic Hill Formation. This contact is thought to be the Clinton-Newberry Fault zone (Wintsch and others, 1998; fig 1) which marks the boundary with the Putnam-Nashoba Terrane.

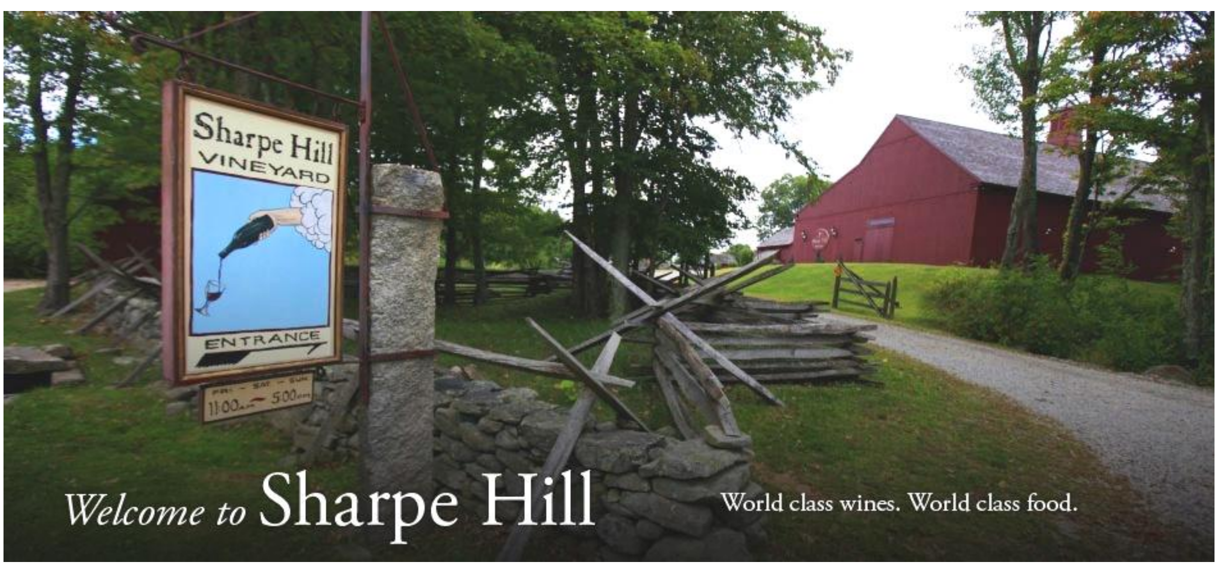
32.1 Turn left onto limited access highway (Rte. 6 Willimantic by-pass).

32.8 Outcrop on left of highly strained Tatnic Hill Formation. Ductile deformation has created tectonic blocks and rare mylonite. This probably is a fault zone that is equivalent to the Lake Char fault zone that was bowed up forming the “Willimantic Dome”, which in reality is a window into the upward bowed Avalon Terrane. (Note: there is a narrow gravel pull-out on the right.)

32.9 Although no outcrops are seen here, the highway crosses east of the fault zone and passes into Avalon Terrane. Outcrops of Avalonian rocks (Zw – part of the Waterford Group) are exposed at off-ramp from Rte. 6W onto Rte. 32 just ahead on left. Bedrock for next 5 miles covered by sand and gravel.

37.4 Limited access highway ends. Turn right at signal.
38.4 Dimension stone quarry behind buildings across from entrance to Home Depot was active during late 19th and early 20th centuries. A beryl bearing pegmatite was also exposed. Outcrops of Waterford Gneiss at Home Depot have mostly been covered. In general for the next several miles, scattered outcrops of the southeast side of the highway are covered by sand and gravel on the left side of the highway.
38.5 View of Windham Airport on left. Large stone structure is part of dike system associated with the Mansfield Hollow Dam which was constructed in response to 1938 hurricane flooding. It has protected Willimantic and other towns downstream from several floods since.
38.8. Esker on left, next to fire house.
39.6 Waterford Gneiss on right.
40.1 Leaving Avalon Terrane. Approximate location of fault zone (not exposed) on northeast side of Willimantic window.
41.4 Approximate boundary of Putnam-Nashoba Terrane with Merrimack Terrane to east.
42.4 Outcrops of Canterbury Gneiss (Dc) on left. Canterbury Gneiss underlies the first vineyard we will visit.
44.1 Entrance to Goodwin Forest/Pine Acres Lake on left.
44.3 Turn left onto West Old Route 6 (short cut to Rte. 97).
45.4 Turn left onto Route 97 in the Village of Hampton.
48.3 Turn right onto Kimball Hill Road. This will become Wade Road.
49.0 Top of unnamed hill that is a drumlin. Kimball Hill is just to north (obscured by trees).
50.0 Turn right into Sharpe Hill Vineyard: STOP 1.

Stop 1. Sharpe Hill Vineyard, 108 Wade Road, Pomfret CT



Sharpe Hill Vineyard sits atop a small drumlin in the town of Pomfret, Connecticut. The area lies within the Iapetos oceanic terrane (Rodgers, 1985) and the underlying bedrock is Canterbury gneiss (**Dc**); belts of Hebron Gneiss (**SOh**) and Scotland Schist (**DSs**) lie to the west and Hebron and Yantic member of Tatnic Hill Formation (**Otay**) are present to the east. The Canterbury Gneiss is a Devonian-aged metaigneous rock unit that intruded sedimentary rocks (Hebron) at 414 Ma (Wintsch and others, 2007).

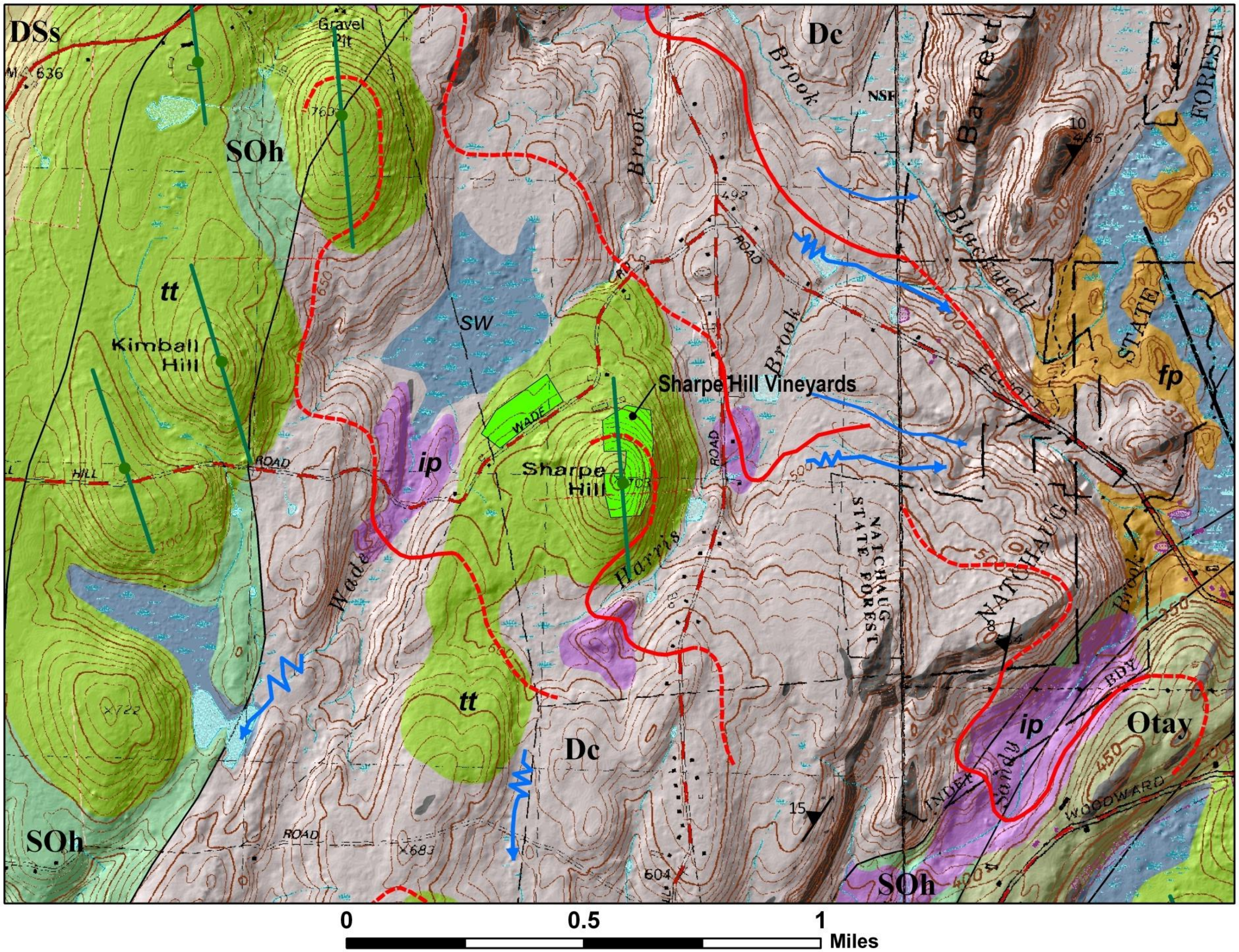


Figure 5. Bedrock and Surficial Geology in the vicinity of Sharpe Hill Vineyards. Geologic units and symbols as defined in Rodgers, 1985; Stone and others, 2005. Dark gray areas are bedrock outcrops from Dixon and Pessl, 1966. **Dc**-Canterbury Gneiss, **SOh**-Hebron Gneiss, **DSs**-Scotland Schist, **Otay**-Yantic member Tatnic Hill Formation, ***tt***-Thick till, ***ip***-Ice-dammed pond deposits, ***fp***-Proximal fluvial deposits, ***sw***-Swamp deposits.

Canterbury gneiss is described as light-gray, medium-grained, porphyoblastic biotite-microcline- oligoclase- quartz gneiss. Accessory minerals are epidote and allanite, muscovite, apatite, sphene, and zircon. Commonly contains half-inch megacrysts of microcline and oligoclase. Inclusions of Hebron Formation can be found near margins. Thin aplite sills are common near base (Dixon and Pessl, 1966).

The northeasterly strike of bedrock ridges is seen in the topography, enhanced in figure 5 by a hillshade of Lidar-generated digital elevation model. The NE rock trend is crossed by NNW-SSE trending, smoother topography produced by thick glacial till deposits (*tt*) that overlie the bedrock. Drumlin hills composed entirely of till such as Sharpe Hill and Kimball Hill (drumlin axes shown by dark green lines) demonstrate the SSE direction of glacial ice advance in this region. The valleys below Sharpe Hill contain small ice-marginal deltaic sand deposits (*ip)* that were built into small glacial ponds dammed by the retreating ice margin (red lines); blue zig-zag arrows are spillways for the small glacial lakes.

Drumlin hills in this area stand at just above 700 ft in altitude and are at the southern extent of a drumlin field that is especially well developed through the town of Woodstock (see fig. 2). The field contains more 200 drumlins and lies down-ice from northeast trending belts of Iapetan schistose rock units including Brimfield and Hebron formations. These more easily erodible rocks provided greater volumes of sediment which became entrained in basal portions of advancing ice sheets and was deposited as lodgment till in drumlins hills. Figure 6 shows an idealized cross-section of a drumlin in southern New England and depicts the presence of two distinctive tills in Connecticut drumlins, which are separated by a weathered zone indicative of former interglacial soil development. These tills were deposited during two separate glaciations. The lower till (also called "old till" or "drumlin till") was deposited during an earlier (probably Illinoian) glaciation. The lower till is primarily a subsurface unit, generally overlain by upper till, but it constitutes the bulk of material in most drumlins. The surface till (or upper till) was deposited during the last Late-Wisconsinan) glaciation. Where both tills are exposed together, the base of the upper till truncates the weathered surface of the drumlin till. The lower part of the upper till commonly displays a zone of shearing and brecciation in which clasts of lower till are mixed and incorporated into upper till. Drumlin till is moderate to very compact, and is commonly finer grained and less stony than the upper (surface) till. The oxidized zone, the lower part of an old soil horizon commonly shows closely spaced joints stained with iron- and manganese-oxides.

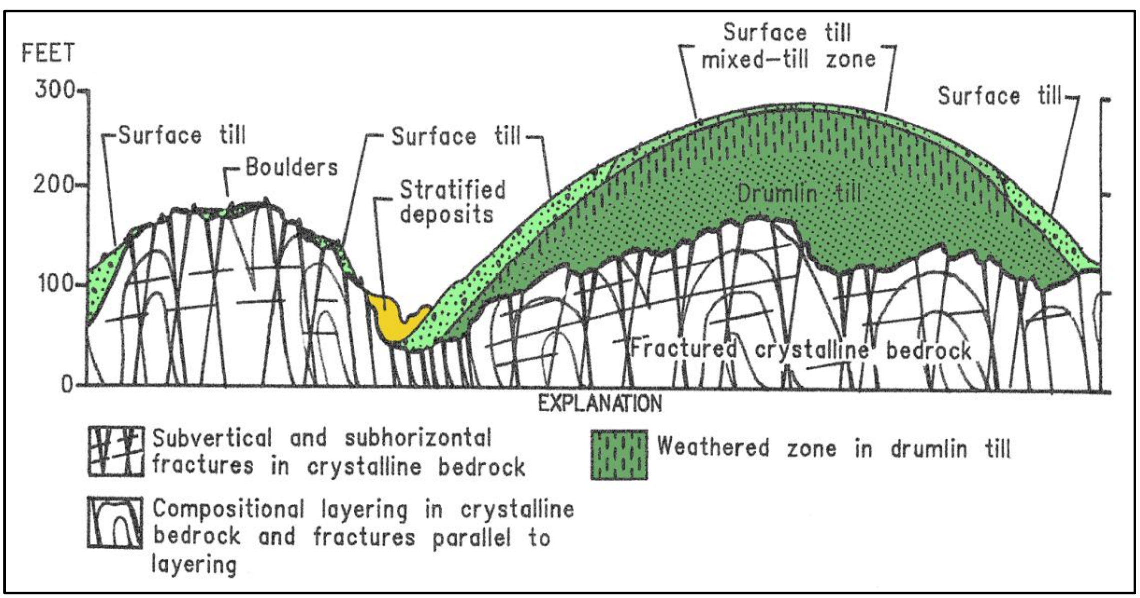


Figure 6. Idealized cross-section of a typical drumlin in southern New England showing the distribution of two distinct tills of different ages. Modified from Melvin and others, 1992.

The view from top of Sharpe Hill is quite extensive. Distant hills to east are Avalon Terrane in Rhode Island. The Quinebaug Lowland is underlain by rock units of the Putnam-Nashoba terrane, including Tatnic Hill and Quinebaug Formations, and contains extensive glacial meltwater deposit—deltas and lake-bottom sediments of glacial Lake Quinebaug. To the north, the view stretches as far as Webster, Massachusetts. Hills of Central Maine Terrane to the northeast are mostly hidden by Kimball Hill (drumlin), but some of the more distant skyline is Central Maine Terrane. To west and south, rocks are all part of Merrimack Terrane.

Mapped soil types at in the vineyard areas include Woodbridge fine sandy loam (45C, 46B, 47C) on the north side of the drumlin, and Canton and Charlton soils (62C, 62D) on the top and south/east sides (fig 7). See Appendix for description of these soils.

Figure 7. Soil Map--State of Connecticut, Sharpe Hill Vineyard, USDA Natural Resources Conservation Service, Web Soil Survey. See Appendix for Soil Unit Descriptions.

Map Unit Symbol	Map Unit Name
3	Ridgebury, Leicester, and Whitman soils, extremely stony
18	Catden and Freetown soils
38C	Hinckley gravelly sandy loam, 3 to 15 percent slopes
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes
45C	Woodbridge fine sandy loam, 8 to 15 percent slopes
46B	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
46C	Woodbridge fine sandy loam, 8 to 15 percent slopes, very stony
47C	Woodbridge fine sandy loam, 2 to 15 percent slopes, extremely stony
58C	Gloucester gravelly sandy loam, 8 to 15 percent slopes, very stony
61B	Canton and Charlton soils, 3 to 8 percent slopes, very stony
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
103	Rippowam fine sandy loam

Figure 7 continued

50.0 Leave vineyard and turn right on Wade Road.
50.4 Turn right onto Cherry Hill Road.
50.8 Cross small area of glacial meltwater deposits (ip, fig. 6) mapped as Hinckley soil (38C, fig.7).
52.3 Enter Putnam-Nashoba terrane.
52.7 Turn right on Rte. 6.
53.2 Pass through roadcut in Canterbury Gneiss.
54.4 Descend down onto glacial meltwater deposits in the Little River valley.
55.8 Turn right on Rte. 97.
57.4 Outcrops of Scotland Schist on left.
60.7 Turn right onto Rte. 14/Rte.97.
61.3 Turn left on Rte. 97. For the next two miles the road is on stratified deposits and associated glacial pond deposits. At about 63 +/- a stream drops off on the right following a glacial melt-water channel. At about 66 +/- several outcrops of Tatnic Hill Formation will be passed. We will be travelling on Tatnic Hill for the next 15+ miles.
67.7 Cross Shetucket River and turn left in Baltic Center, following Rte. 97.
70.2 Rte. 97 jogs left and then right in mill town of Occum. Road will go under I-395 in about a mile.
72.2 Spectacular old mills in Taftville.
73.3 Merge onto Rte. 12 (Rte. 97 ends).
74.2 Follow Rte. 12 (signage difficult here).
76.0 Turn left onto Rte. 2E. Numerous outcrops of Tatnic Hill along Rte. 2.
78.8 Turn right onto Rte. 2A/Rte. 117.
79.7 Continue straight on Rte. 117. Rte. 2A bears right.
79.8 Turn left following Rte. 117. Road crosses Honey Hill Fault and into Avalon Terrane just south of this intersection. The fault is not exposed because glacial meltwater deposits fill the valley.
81.8 Hope Valley Alaskite Gneiss (Zsh) outcrop. Several other small outcrops of Zsh may be noticed nearby. Hope Valley forms the core of the Willimantic Dome.
82.2 Spicer Hill Road on left.
82.4 Turn right into Maugle Sierra Vineyard. STOP 2. *NOTE: this is private property and only open to the public at specified times. Check ahead.*

Stop 2. Maugle Sierra Vineyard, 825 Colonel Ledyard Highway (Rt. 117), Ledyard CT

Maugle Sierra vineyard is situated down in a small valley in the town of Ledyard. Having crossed the Honey Hill fault on Rt. 117 a few miles back, we are now in the Avalonian terrane. The Honey Hill is a major thrust fault zone in which rocks of the small Avalonian continent collided with the rocks of Iapetus oceanic terrane during the Alleghenian (Permian) orogeny. Bedrock beneath the vineyard is Hope Valley alaskite gneiss (Zsh), which is light-pink to gray, medium- to coarse-grained, locally porphyritic, variably lineated and foliated alaskitic gneiss, composed of microcline, quartz, albite or oligoclase, and minor magnetite, and locally biotite and muscovite. Lineation formed by rods of quartz. Locally contains quartz-sillimanite nodules; Hope Valley is a Neoproterozoic-aged granitic metaigneous rock that intruded Plainfield Formation (Zp) and other Waterford Group gneisses (Zw, Zwm). The east-west trending strike of foliation in the Avalonian rock units in this area can be seen in the E-W trend of bedrock ridges (fig. 8); strike ridges are cut by north-south trending brittle faults and fractures that are probably Mesozoic in age.

Glacial deposits in the area include bouldery ridges of the Ledyard recessional moraine (*hlem*) and ice-marginal glaciofluvial (*gr*) and glaciodeltaic (*led*) meltwater deposits laid down as the late-Wisconsinan ice retreated from the area (ice-margin positions indicated by red lines in figure 8; spillways for glacial lakes are indicated by blue zig-zag arrows). Areas of thick glacial till (tt) on the north sides of bedrock hills are present in the area, but the vineyards fields at Maugle Sierra lie mostly on cobbly gravel of Groton proximal meltwater stream deposits (gr). The vineyards are planted on the ice proximal head of this deposit near where the ice-margin stood during deposition; as a result the texture of glaciofluvial deposits here is quite coarse—cobble, boulder gravel that can be seen in a small borrow pit just west of the western field.

Mapped soils at Maugle Sierra include Hinckley gravelly sandy loam (38C), Agawam fine sandy loam (29B) developed on the glacial meltwater deposits, and Canton and Charlton soils (62C) on the eastern till slope (see fig. 9). Paul Maugle, owner and vintner at Maugle Sierra, believes that the very stony and gravelly soils at the vineyard cause the roots to grow deeper making the vines stronger and more vigorous in the production of grapes. He sees this valley location near Long Island Sound as an ideal terroir, where grape vines are protected from wind, storms, and cold, and the mists that settle in off the water provide the best in moisturizing effects.

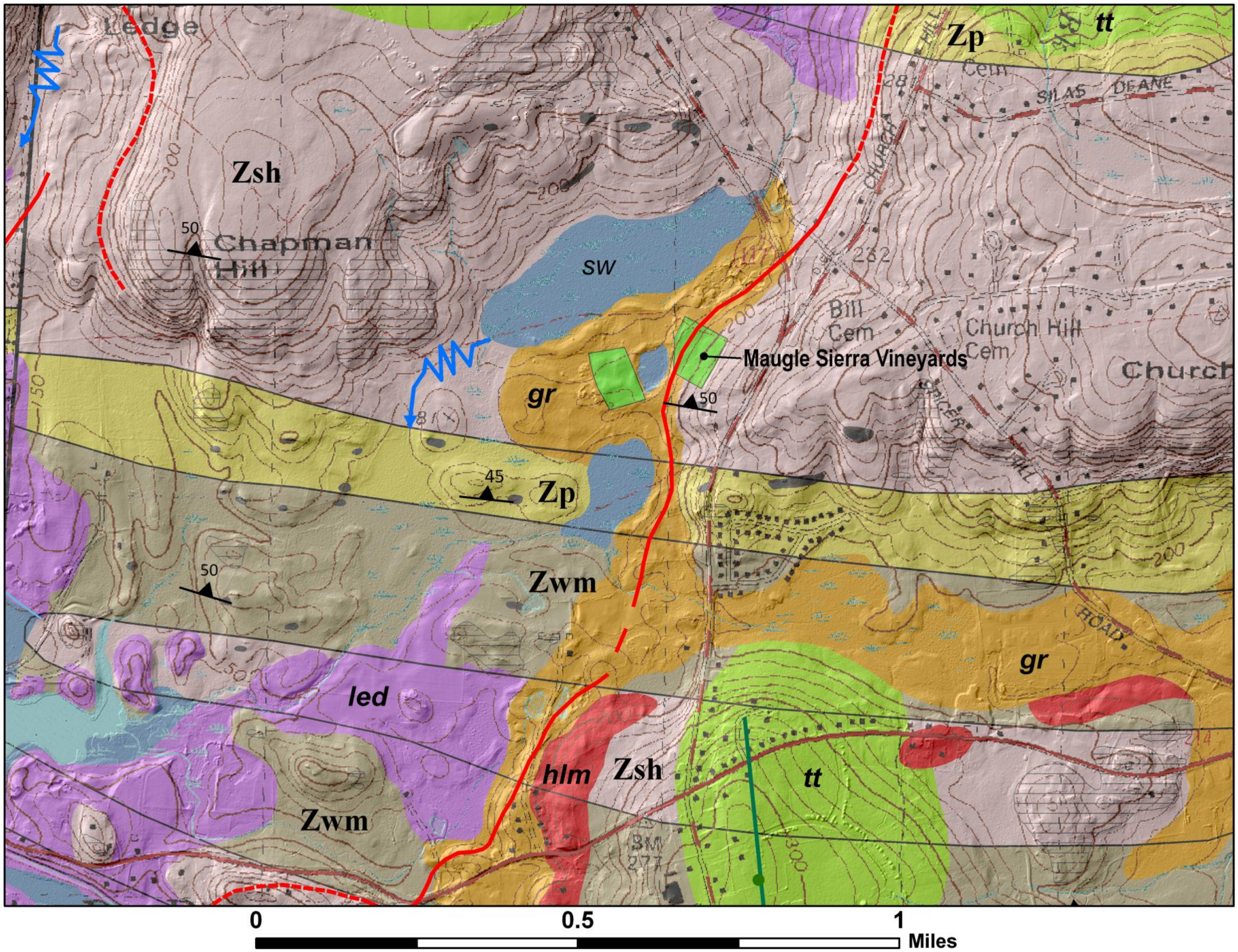


Figure 8. Bedrock and Surficial Geology in the vicinity of Maugle Sierra Vineyards. Geologic units and symbols as defined in Rodgers, 1985; Stone and others, 2005. Dark gray areas are bedrock outcrops from Goldsmith, 1967. **Zsh**-Hope Valley Alaskite Gneiss, **Zp**-Plainfield Formation, **Zwm**-Mamacoke Gneiss, ***gr***-Groton proximal fluvial deposits, ***led***-Ledyard ice-dammed pond deposits, ***hlm***-Hammonassett-Ledyard moraine deposits, ***tt***-Thick till deposits, ***sw***-Swamp depositis

Map Unit Symbol	Map Unit Name
3	Ridgebury, Leicester, and Whitman soils, extremely stony
13	Walpole sandy loam
15	Scarboro muck
17	Timakwa and Natchaug soils
18	Catden and Freetown soils
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes
29B	Agawam fine sandy loam, 3 to 8 percent slopes
38C	Hinckley gravelly sandy loam, 3 to 15 percent slopes
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky

Figure 9. Soil Map--State of Connecticut, Maugle Sierra Vineyards, USDA Natural Resources Conservation Service, Web Soil Survey. See Appendix for Soil Unit Descriptions

82.4 Turn right out of driveway onto Rte. 117.
82.7 Outcrop of Mamacoke Formation (Zwm).
83.1 Turn right onto Rte. 214.
84.2 Intersecting Whalehead Road. Note abundance of large boulders. Road crosses discontinuous Hammonaset-Ledyard Moraine For OPTIONAL STOP to see moraine turn left here. Scattered bedrock outcrops in this area are gneisses of the Plainfield Formation (Zp).

Road log for OPTIONAL STOP at Glacier Park, Ledyard.

0.0 Turn left onto Whalehead Road and reset mileage log to 0.0. Note boulders along road which are part of Hammonsett-Ledyard Moraine (recessional). Road will gradually curve around to right passing three local intersections. Third is Tanglewood Road.
0.9 After passing Tanglewood Road on left, turn right under power lines into parking area for Glacier Park.

Optional Stop. Ledyard Glacial Park-- a section of the Hammonassett-Ledyard recessional moraine.

The Hammonassett-Ledyard moraine (Stone and others, 2005) extends from Meigs Point at Hammonassett State Park in Madison, crosses the Connecticut River just north of the I-95 bridge and the Thames River just south of the Rt. 2 bridge, continues through Ledyard and then eastward into Rhode Island. This moraine and others like it in southeastern Connecticut were first recognized and mapped by Richard Goldsmith of the USGS. This glacial park location has been described for several previous fieldtrips including Stone and others (1998); the following is excerpted from Goldsmith (1987).

Figure 10. Bouldery section of the Ledyard Moraine in Glacial Park off Whalehead Road. *Black Dog* for scale.

A trail prepared by the Ledyard Conservation Commission (Maire, 1976) leads from Whalehead Road at the power line to an unusual concentration of boulders, first noted by Wells (1890), that forms this part of the Ledyard moraine. The main trail proceeds clockwise from the south flank of the boulder concentration across a ravine, turns around a bedrock ledge and then back across the ravine, and traverses over the boulder concentration as it rises up the hill to the northeast. Near the top of the hill, the trail follows the north edge of the boulder concentration, recrosses the moraine (which here has a less bouldery aspect), and returns out along the south side of the moraine. The unusual concentration of boulders without interstitial fine material is attributed to an abundance of granitic source material accumulated in the "dirt machine" (Koteff and Pessl, 1981) and to sorting of this material by slumping that was contemporaneous with winnowing by meltwater, possibly in a crevasse. The presence of ledges of bedrock beneath the moraine at the side of the ravine and to the east near the power line indicates that till is relatively thin in the area. The boulders at Glacial Park and elsewhere in the Ledyard Moraine are derived primarily from rock types that have widely spaced joints and poor or no fissility. Most are derived from ledges within 0.6 to 1.2 miles to the north and generally within less than 3 miles (fig. 6, Goldsmith, 1967), but a few have been transported greater distances. East-northeast of Glacial Park, the moraine continues as local areas of boulder concentrations and as areas of boulder till that appear to form a double moraine. The distribution of the moraine in this area has not been mapped in detail. Immediately west of Glacial Park, the moraine appears to be dispersed. Here many large erratic are scattered on an irregular and largely bedrock controlled surface. The moraine, however, emerges as a discrete feature from beneath stratified deposits northeast of Maynard Hill.

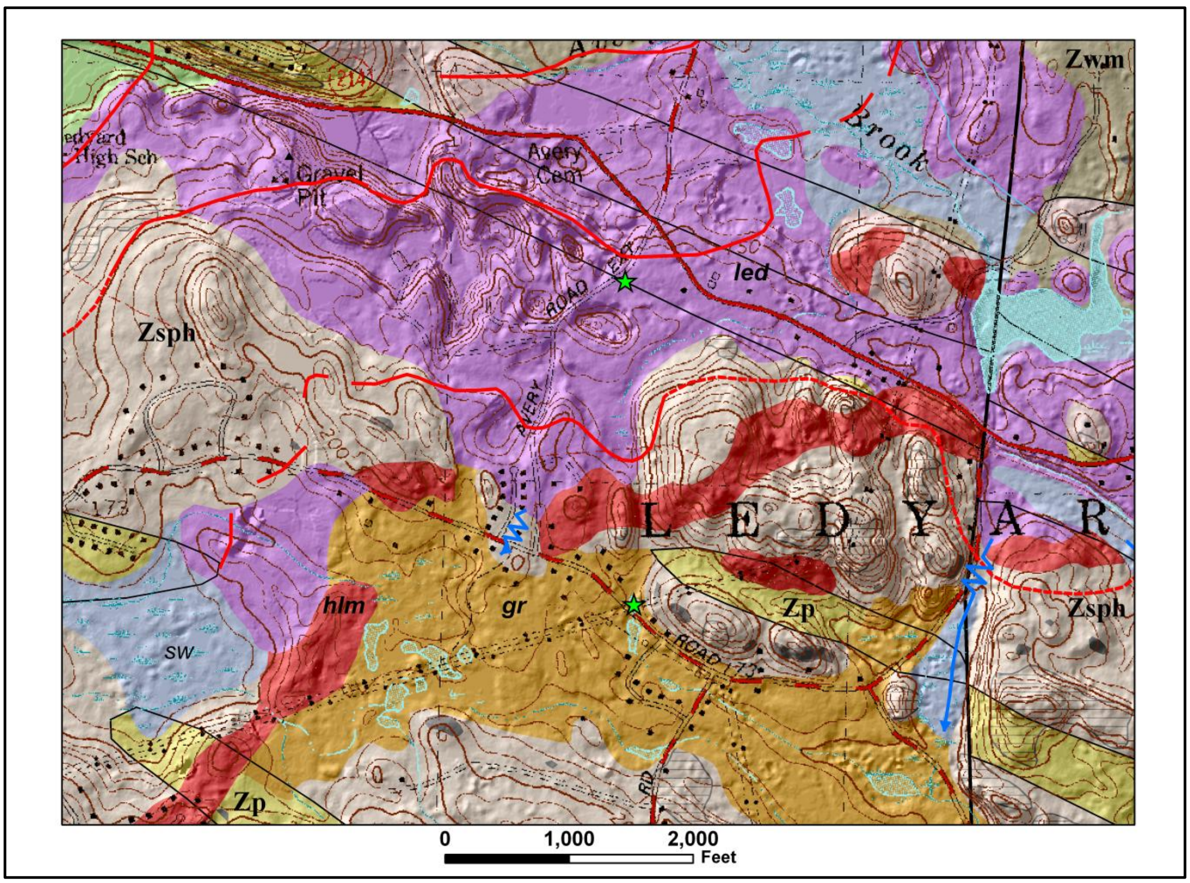


Figure 11. Bedrock and surficial geology in the vicinity of Glacial Park in Ledyard. Geologic units and symbols as in Rodgers, 1985; Stone and others, 2005. Bedrock outcrop areas in dark gray are from Goldsmith, 1967. Green stars indicate locations of boulder moraine trailhead off Whalehead Road and glacial kettle park off Avery Road.

0.9 Turn right out of park drive back onto Whalehead Road.
1.1 Turn right onto Avery Hill Road Extension.
1.6 Parking (limited) for Kettle Hole Trail.
Excellent examples of glacial kettles, depressions where detached blocks of ice melted out, can be seen on both sides of the road here. The glacial meltwater deposits in which the kettles occur are Ledyard Ice-dammed Pond deposits (*led*) consisting of sand and gravel deposited as deltas in a small glacial lake that was impounded by the retreating ice-margin to the north and spilled through a spillway (blue zigzag arrow) that was the low point across drainage divide to the south.
Return to vehicles and continue on Avery Road Ext.
1.8 Turn left onto Rte. 214 and resume road log at mile 84.8.

84.8 Avery Hill Road Extension, where optional stop returns to field trip log. Road travels over Hope Valley Alaskite Gneiss and then Plainfield Formation.
86.0 Turn right onto Rte. 12. Thames River Estuary on left.
86.1 Hope Valley Alaskite Gneiss outcrops.
86.5 Mamacoke Formation outcrops.
87.2 Hope Valley outcrop
88.2 Turn left onto Rte. 2A west; on east side of Thames River, road crosses flat-topped terrace underlain by deltaic sand and gravel deposits of glacial Lake Uncasville. Access road to Mohegan Sun Resort (casino) on right has excellent outcrops of Hope Valley alaskite gneiss (Zsh) and Waterford group rocks (Zw) (fig. 9).
88.9 Outcrops on right are Hope Valley (pinkish) and then Waterford group (gray gneiss).

Figure 12. Outcrops of Hope Valley alaskite gneiss and Waterford Group gneisses along the north side of Rte. 2A in Montville.

90.5 Right onto I-395 north. Outcrops of Hope Valley Alaskite Gneiss at merge. Note topography change ahead. Our route leaves (temporarily) Avalon Terrane and crosses the Honey Hill Fault and onto the Putnam-Nashoba Terrane. Here the alaskite gneiss supports a higher topography than the Tatnic Hill Formation.
91.9 Exit at Rte. 82 (exit 80); turn left at bottom of ramp (stop light) onto Rte. 82 west.
92.6 Outcrop of rusty weathering Tatnic Hill Formation. Look out to left to observe the escarpment maintained by the Avalonian rocks on the south side of the Honey Hill Fault, which lies at the base of the topographic rise.

94.1 Crossing back onto Avalonian Terrane. Outcrops along curve in road over next mile or so are Hope Valley and then Rope Ferry Gneiss.

101.0 Intersection with Rte. 85 in Salem. Continue straight on Rte. 82.

102.0 Turn right onto Rte. 11 expressway. Outcrop ahead is Rope Ferry Gneiss. Here the Rope Ferry is a biotite gneiss with amphibolites. Boundaries of amphibolites tend to be shear planes and amphibolite foliation typically is cut by these planes. Many shear planes along this stretch of Rte. 11 have been reactivated since the highway was constructed. Drill hole scars show thrust offset across many planes. Updip movement as much as 43 cm was recorded across some shear planes further ahead in the Brimfield Schist. Here one shear plane has seen such reactivation, but movement was only a few centimeters; probably represents stored regional strain in the rock, released when exposures were created during highway construction.

Figure 13. Offset drill-hole scars in Rope Ferry Gneiss, Rte. 11, east side of highway.

Figure 14. Hebron Formation exposed on northbound Rte. 11 near Exit 5 (Witch Meadow Road). Note presence of numerous rotated pegmatite boudins.

103.0 Approximate location of Honey Hill Fault. Cross in short distance onto Merrimack Terrane. Next outcrops (at about 103.8) consist of Hebron Gneiss with abundant boudinaged pegmatite.

104.6 Cross into Central Maine Terrane. Hebron gneiss exposed along highway at exit 5 (Witch Meadow Road) but rusty weathering Brimfield Schist is exposed beneath the overpass for Witch Meadow Road and on entrance ramp from Witch Meadow road just beyond. Outcrops for some distance will be of Brimfield Schist (Obr). Offset drill hole scars reported, mostly on southbound side of Rte. 11. Dip of foliation appears to flatten, however road is oriented nearly

parallel to strike and foliations actually dips northwest (toward left) about 20-30^{o}.

Figure 15. Outcrop of Brimfield Schist (Obr) along Rte. 11. This is the rock unit underlying Priam Vineyards at our next Stop; it is not exposed there.

108.6 Merge from left with Rte. 2.

112.6 Leave Rte. 2 at Exit 16.

112.8 Turn right at end of exit ramp onto Rte. 149.

114.8 Turn right onto Shailor Hill Road and then left into driveway of Priam Vineyards for Stop3. *NOTE: this is private property and only open to the public at specified times. Check ahead.*

Stop 3. Priam Vineyards, -- Shailor Hill Road, Colchester, CT

Priam Vineyards sit high in the landscape at 450-530 ft in altitude on the north side of a bedrock hill in the town of Colchester (fig. 16); the vineyards are underlain by thick glacial till deposits. The till-draped bedrock upland is bounded to the west by the Salmon River valley, to the north by Jeremy Brook valley, and to the east by the north-sloping valley of Pine Brook. Bedrock in immediate area is Brimfield Schist (Obr) which is quite different in character from the more gneissic rock at previous vineyards. The Brimfield Schist was deposited as a sedimentary sequence of sulfidic shales and siltstones in the Iapetus Ocean (Central Maine Terrane) and is now believed to be Late Silurian-Early Devonian (420-415 Ma) (Wintsch and others, 2004, 2007) based on dating of detrital zircons.

Lungren, Ashmead, and Snyder (1971) describe the Brimfield Schist as follows: "the dominant rock type seen in natural exposures in the Brimfield Schist is coarse-grained, silvery gray, biotite-muscovite schist with quartz and plagioclase in discontinuous lenses and folia and in augenlike aggregates. In large exposures, it has a migmatitic or gneissic aspect. Generally it is spotted with small (1-2 mm) red garnets and contains traces of iron oxide (magnetite-ilmenite), graphite, and iron sulfide (pyrite or pyrrhotite). Muscovite is in scattered single flakes, in laminae consisting of randomly oriented small crystals, and in conspicuous porphyroblasts 5-10 cm across, Fine sillimanite needles are present and, locally, coarse-grained aggregates of sillimanite and quartz that appear in outcrop as silky white lenses. Exposures made during construction of Rte. 2 suggest that the schists seen in natural outcrops represent the most feldspathic, least micaceous, and least sulfidic variants of the schist. Artificial exposures display highly micaceous schist that deteriorates rapidly on exposure to the atmosphere by the conversion of sufide (pyrrhotite) to yellow- and reddish-brown iron oxides and white sulfates that quickly encrust the exposures. It appears that these rapidly deteriorating schists contain more muscovite and graphite that the schists in most large natural exposures."

The lidar-enhanced topographic map (fig. 16) clearly shows the rugged and steep slopes on the southeast side of the upland area underlain by Brimfield Schist and the smoother northwest side (where the vineyards lie), which is blanketed with thick till deposits (tt). Wells indicate that the till is as much as 40 ft thick in this vicinity and likely includes old (lower/drumlin) till at depth.

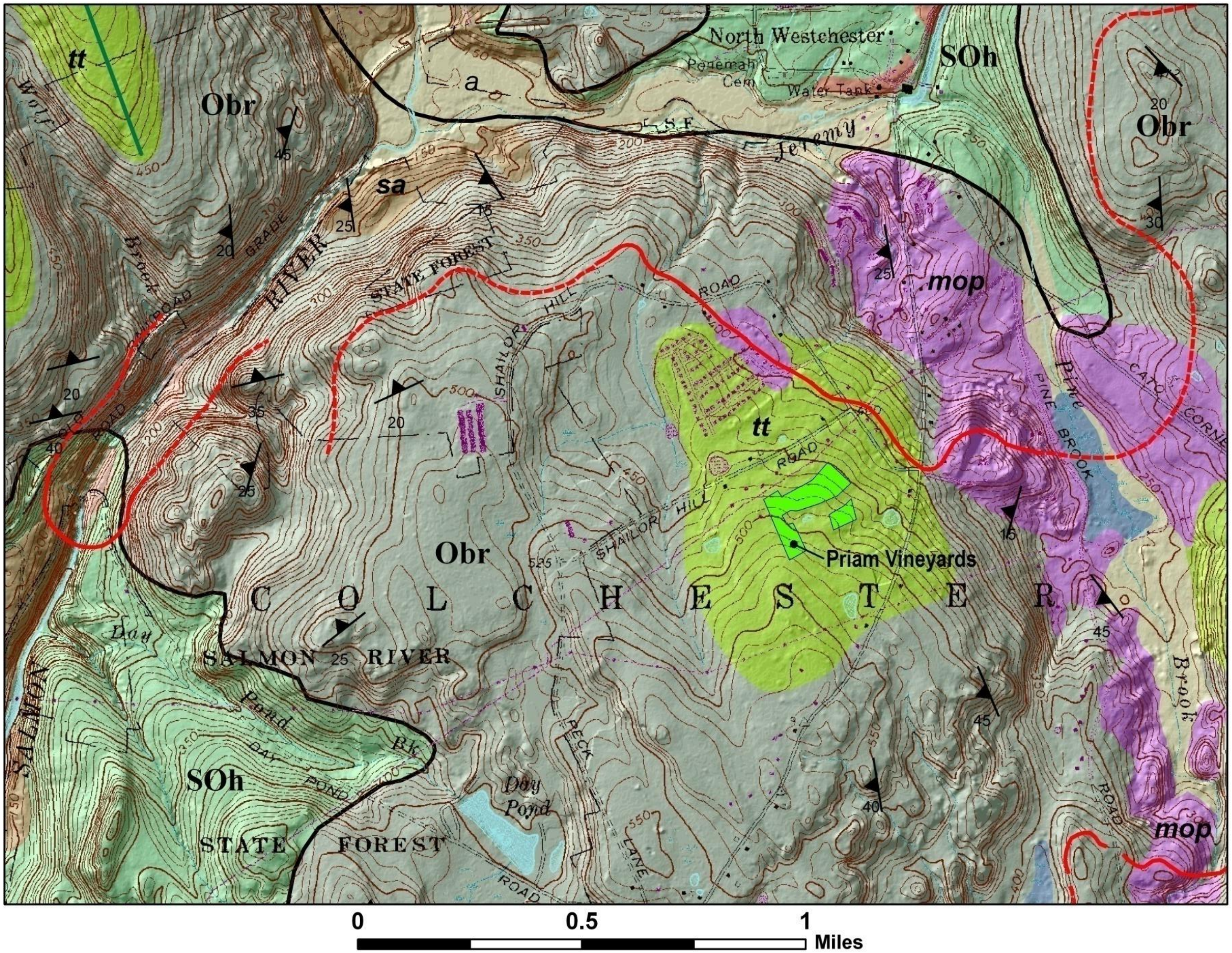
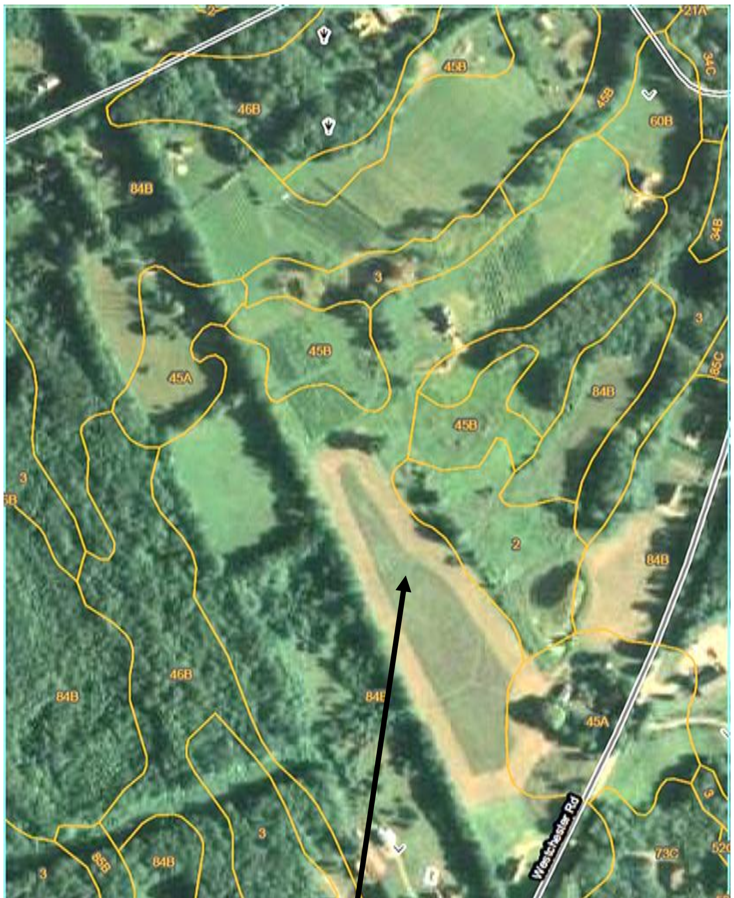


Figure 16. Bedrock and Surficial Geology in the vicinity of Priam Vineyards. Geologic units and symbols as in Rodgers, 1985; Stone and others, 2005. **Obr**-Brimfield Schist, **SOh**-Hebron Gneiss, ***tt***-Thick till, ***mop***-Moodus River divide-Pine Brook ice-dammed pond deposits, ***sa***-Salmon River sediment-dammed pond deposits, ***a***-Floodplain alluvium.

Mapped soils on the till deposits in the vineyard area include Paxton and Montauk soils (84B) and Woodbridge fine sandy loam (45A, 45B) (fig.17). Owner and vintner of Priam, Gary Crump, has graciously dug a 5-ft deep soil test pit (fig. 18) so that we may examine the vineyard soil. He believes that his Gewurztraminer and Riesling wines (aged in steel, not oak) produce mineral notes on the palate and best represent Priam's particular terroir. The local Paxton soil is developed on glacial till that was derived from iron-oxide and iron-sulfide bearing Brimfield Schist that perhaps imparts a particular mineral taste to the wine.



Map Unit Symbol	Map Unit Name
2	Ridgebury fine sandy loam
3	Ridgebury, Leicester, and Whitman soils, extremely stony
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes
34B	Merrimac sandy loam, 3 to 8 percent slopes
34C	Merrimac sandy loam, 8 to 15 percent slopes
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes
46B	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
52C	Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony
60B	Canton and Charlton soils, 3 to 8 percent slopes
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony
85C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes, very stony

Figure 17. Soil Map--State of Connecticut, Priam Vineyards, USDA Natural Resources Conservation Service, Web Soil Survey. See Appendix for Soil Unit Descriptions.

Figure 18. Soil test pit in upper field at Priam Vineyards (not yet planted with grapes). Mapped soil unit here is 84B, Paxton and Montauk fine sandy loam, 3-8% slopes

While glacial till directly underlies the vineyard fields, just across Rt. 149 in the valley of Pine Brook, which drains to the north and joins Jeremy Brook, a small glacial lake existed dammed to the north by the retreating ice margin (red lines fig. 16). Ice-marginal deltaic sand and gravel (mop, Moodus River divide-Pine Brook deposits) with uncollapsed surfaces at 395 ft in altitude were deposited in the small glacial lake that spilled across the modern drainage divide through Babcock Swamp at 375 ft in altitude, several miles south of here. Sandy delta foreset beds (fig. 19) are exposed in a sand pit which can be seen off Pine Brook Road to the east of the vineyard.

Figure 19. Prezcopski Sand Pit across the road from Priam Vineyards. Exposes sandy delta foreset beds of the Pine Brook valley ice-dammed pond deposits (mop). Note slabby boulder of rusty Brimfield Schist in foreground. Private property, please do not enter without permission.

Turn right out of Priam Vineyards driveway onto Shailor Hill Road.

115.1 Turn left onto Rte. 149.
117.0 Turn left onto Rte. 2.
118.3 Outcrops of Hebron Gneiss (Merrimack Terrane).
121.4 Approximate position of Higganum Dike (based on aeromagnetic data…no exposure here).
123.5 For about a mile from here we are on Brimfield Schist again (Central Maine Terrane)
124.7 Littleton Formation (Bronson Hill Terrane)
125.2 Outcrops of Glastonbury Gneiss which is the rock type at our next vineyard stop.
130.2 High bank on west side of highway is frontal slope of 525-ft ice-marginal delta built into glacial Lake Dickenson (Langer, 1977). Pink sands can be seen along the highway for about a mile here. These meltwater deposits contain a high percentage of Mesozoic-rock derived clasts despite the fact that they are about three miles down ice from the Eastern Border fault.

127.2 Take Exit 10 for Crystal Ridge Vineyard (**if there is time**)

000.0 Turn left at end of ramp onto Manchester Road (Rte. 83 south). In short distance, this forms a T with New London Turnpike.
000.2 Turn right onto New London Turnpike. Descend onto glaciodeltaic deposits of Glacial Lake Roaring Brook
000.8 Turn left onto Chestnut Hill Road.
001.5 Turn left onto Hopewell Road.
002.0 Bear right onto Woodland Road.
002.3 Leaving glacial meltwater deposits and ascend onto thin till covered bedrock. Outcrops of Glastonbury Gneiss on steep cliffs on right side of road.
003.5 Turn left onto Clark Hill Road.
004.1 Turn right on Crystal Ridge Road and proceed to cul-de-sac turn-around. If gate is open, drive down hill to the vineyard. *Note: this is private property onto which we have received advance permission to enter on this specific date.*

Vineyard Stop 4. Crystal Ridge Vineyard, 257 Belltown Road, South Glastonbury, CT

This vineyard that does not yet have a winery lies in a small valley near the western side of the Bronson Hill (Island Arc) terrane (fig. 20). Westerly views from the tops of Belltown Hill and Clark Hill are expansive vistas of the Hartford Basin, it's contained glacial lake surfaces, and the Connecticut River valley. Bedrock outcrops are common in the vineyard area, and are Glastonbury Gneiss (Ogl), a gray, medium- to coarse-grained, massive to well-foliated granitoid gneiss composed of oligoclase, quartz, microcline, and biotite (as patches), also epidote and hornblende in many areas, commonly associated with layers of amphibolite; elsewhere minor muscovite and garnet (Herz, 1955). About 1.5 miles west of the vineyard, a belt of Collins Hill Formation (Och) contains excellent mineral collecting localities in several old pegmatite quarries (info at-- http://www.johnbettsfineminerals.com/jhbnyc/articles/glastonb.htm).

The Mesozoic eastern border fault buried by glacial meltwater deposits along the west edge of the Collins Hill belt separates Bronson Hill terrane from Jurassic-aged Portland Arkose (Jp) in the Hartford Basin.

Glacial deposits in the immediate vicinity of the vineyard consist of thin (less than 10-15 ft) glacial till. The field lies several miles southeast of the red Mesozoic rocks, so the till is mainly gray, upper till derived from the gray metamorphic rock units (Glastonbury and Collins Hill) Glacial meltwater deposits are present in nearby Hales Brook and Roaring Brook valleys, which contained small ice-dammed glacial lakes (red lines are ice-margin positions). In the Connecticut valley, ice-marginal deltaic deposits of glacial Lake Middletown (Mc) and Dividend Brook deposits contain excellent examples of kettle ponds (Great Pond, Potter Pond). Together these deltaic deposits, which also occur across the Connecticut River, formed the Rocky Hill Dam that impounded Glacial Lake Hitchcock, New England's longest glacial lake.

Mapped soils at Crystal Ridge include Woodbridge (46B) and Canton-Charlton (60D).

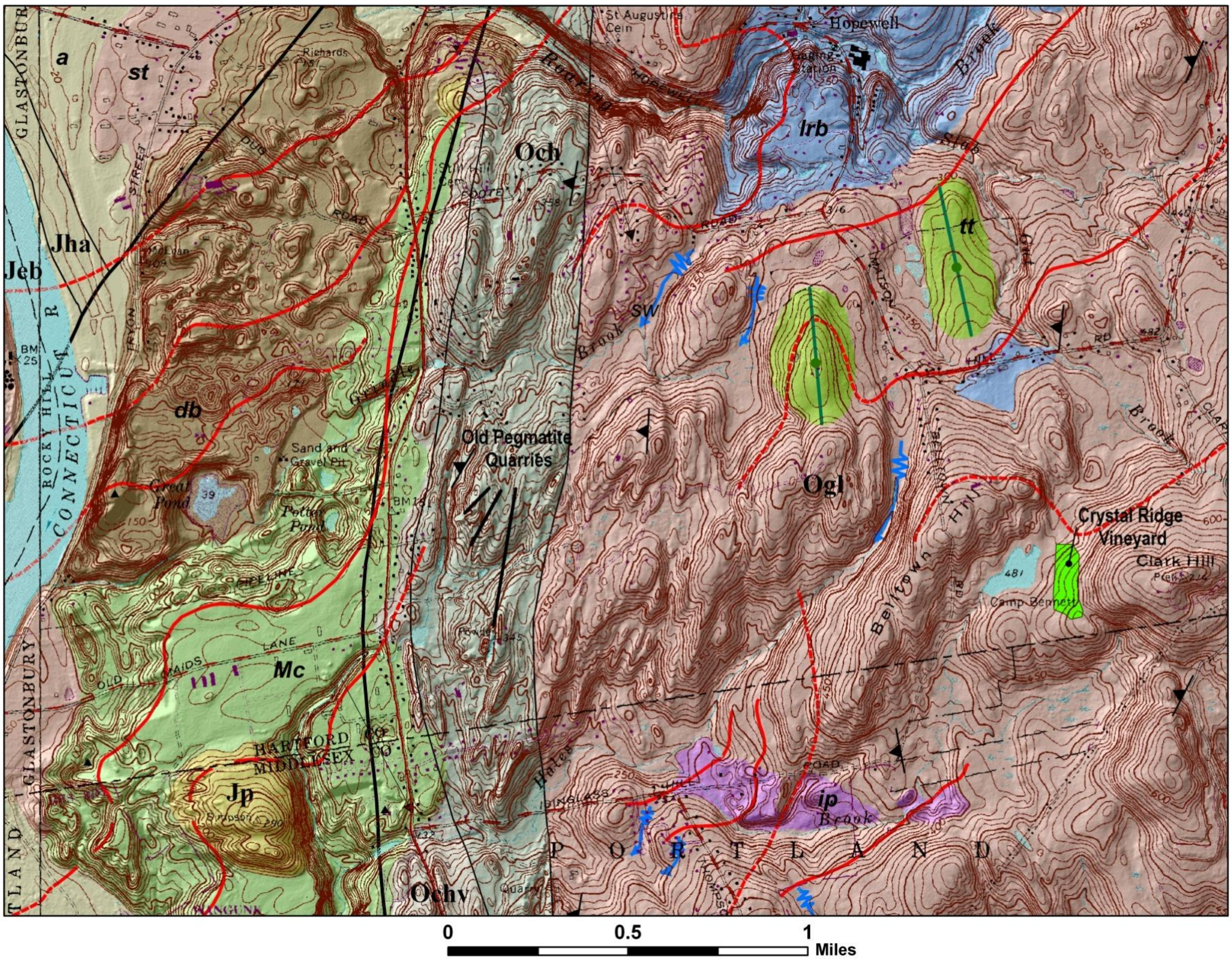


Figure 20. Bedrock and Surficial Geology in the vicinity of Crystal Ridge Vineyard. Geologic units and symbols as defined in Rodgers, 1985; Stone and others, 2005. **Ogl**-Glastonbury Gneiss, **Och**-Collins Hill Formation, **Jp**-Portland Arkose, **Jha**-Hampden Basalt, **Jeb**-East Berlin Formation, ***tt***, Thick till deposits, ***lrb***-Glacial Lake Roaring Brook deposits, ***Mc***-Glacial Lake Middletown deposits, ***db***-Dividend Brook sediment-dammed pond deposits, ***st***-Stream terrace deposits, ***a***-Floodplain alluvium.

Map Unit Symbol	Map Unit Name
3	Ridgebury, Leicester, and Whitman soils, extremely stony
46B	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
60C	Canton and Charlton soils, 8 to 15 percent slopes
60D	Canton and Charlton soils, 15 to 25 percent slopes
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes

Figure 21. Soil Map--State of Connecticut, Crystal Ridge Vineyard, USDA Natural Resources Conservation Service, Web Soil Survey. See Appendix for Soil Unit Descriptions.

004.7 Continue west on vineyard dirt road and turn right on Belltown Road.
005.3 Turn left on Matson Hill Road. Note outcrops of Glastonbury Gneiss on left (west) side of road; drumlin hill sits higher in altitude above outcrops covered with orchards.
005.8 Turn left on Foote Road.
006.2 Note 285-ft meltwater spillway for glacial Lake Roaring Brook (lrb) to the left going southwest from bend in road.
006.6 Cross contact with Collins Hill Formation; note small outcrops on both sides of road.
007.1 As slope flattens, cross Mesozoic Eastern border fault which lies beneath glacial meltwater deposits of glacial Lake Middletown (Mc); delta surface at 195 ft in altitude.
007.2 Turn right (north) on Rt. 17.
007.7 Cross floodplain of Roaring Brook; traveling over incised stream-terrace surface carved by Roaring Brook and the Connecticut River after Lake Hitchcock drained.
007.9 Straight at Stop light (unless you want to turn left on Rt. 160 and take the Glastonbury-Rocky Hill Ferry across the River to Dinosaur Park… but the ferry does take the busses.
009.3 Continue straight at Stop light onto connector road heading to Rte. 2 west
011.1 Merge left onto Rte 2 west toward Hartford.
012.3 Take exit 5D onto Rte. 3W
Follow directions below from mile 130.4

129.0 View into Mesozoic Hartford Basin. Distant skyline of Western Highlands.
129.3 Last outcrop of Glastonbury Gneiss. Eastern Border Fault lies between here and the valley lowlands. Rodgers map (1985) shows it about 0.3 miles east of Exit 9.
130.4 Take exit 5D onto Rte. 3W
136.0 Exit left to I-91S.
138.9 Low outcrops of Holyoke Basalt mark axis of Rocky Hill anticline.
139.6 Overgrown outcrops of East Berlin Formation on center median (left).
140.3 Exit 23 (West Street). Turn left at end of ramp.
142.3 Turn right into Dinosaur State Park parking lot.

References cited

Dixon, H.R., and Pessl, Fred, Jr., 1966, Geologic Map of the Hampton quadrangle, Windham Co., Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ–468, scale 1:24,000.

Goldsmith, Richard, 1960, Surficial geology of the Uncasville quadrangle, Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ–138, scale 1:24,000.

Goldsmith, Richard, 1967, Bedrock geology of the Uncasville quadrangle, Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ–576, scale 1:24,000.

Goldsmith, Richard, 1982, Recessional moraines and ice retreat in southeastern Connecticut, *in* Larson, G.J., and Stone, B.D., eds., Late Wisconsinan glaciation of New England: Dubuque, Iowa, Kendall/Hunt Publishing Co., p. 61–76.

Herz, Norman, 1955, The Bedrock Geology of the Glastonbury Quadrangle (with map): State Geological and Natural History Survey of Connecticut Quadrangle Report No. 5, scale 1:31,680, 22 p.

Koteff, Carl, and Pessl, Fred, Jr., 1981, Systematic ice retreat in New England: U.S. Geological Survey Professional Paper 1179, 20 p.

Langer, W.H., 1977, Surficial geologic map of the Glastonbury quadrangle, Hartford and Middlesex counties, Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ– 1354, scale 1:24,000.

Lehman, Eric D., and Nawrocki, Amy, 2011, A History of Connecticut Wine: Vineyard in your backyard: The History Press, Charleston, S.C., 127 p.

Lungren, L., Jr., Ashmead, L., and Snyder, G.L., 1971, The Bedrock Geology of the Moodus and Colchester quadrangles (with maps); State Geological and Natural History Survey of Connecticut, Quadrangle Report No. 27, 23 p.

Maire, B.L.,1976, Ledyard Glacial Park, Ledyard Conservation Commission, 19 p.

Melvin, R.L, De Lima,Virginia, and Stone, B.D., 1992, The stratigraphy and hydraulic properties of tills in southern New England: U.S. Geological Survey Open-file Report 91-481, 49 p.

O'Leary, D.M., 1975, Surficial geologic map of the Moodus quadrangle, Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ–1205, scale 1:24,000.

Rodgers, John, comp., 1985, Bedrock geological map of Connecticut: [Hartford] Connecticut Geological and Natural History Survey, 2 sheets, scale 1:125,000.

Stone, J. R., Schafer, J. P., London, E. H., DiGiacomo-Cohen, Mary, Lewis, R.S., and Thompson, W. B., 2005, Quaternary geologic map of Connecticut and Long Island Sound Basin, with a section on sedimentary facies and morphosequences of glacial meltwater deposits by B. D. Stone and J. R. Stone: U.S. Geological Survey Scientific Investigations Map SIM-2784, 2 plates and pamphlet 72 p., map scale 1:125,000.

Stone, J. R., DiGiacomo-Cohen, M.L., Lewis, R.S, and Goldsmith, Richard, 1998, Recessional moraines and the associated deglacial record of southeastern Connecticut, *in* Murray, D.P., (ed.) New England Intercollegiate Geological Conference 90th Annual Meeting, Kingston, RI, Oct. 9-11, 1998, Guidebook to Field Trips in Rhode Island and adjacent regions of Connecticut and Massachusetts Trip B7, p. B7-1-B7-20.

Walsh, G.J., Aleinikoff, J.N., and Wintsch, R.P., 2007, Origin of the Lyme dome and implications for the timing of multiple Alleghanian deformational and intrusive events in southern Connecticut: American Journal of Science, v. 307, no. 1, p. 168–215.

Wells, D.H.,1890, Evidences of glacial action in southeastern Connecticut: Popular Science Monthly, v. 37, p. 691-703.

Wintsch, R.P., Kunk, M.J., and Aleinikoff, J.N., 1998, The Hinterland of the Alleghanian Orogen in southern New England: Late Paleozoic metamorphic and structural overprint on Acadian metamorphic rocks, *in* Murray, D.P., (ed.) New England Intercollegiate Geological Conference 90th Annual Meeting, Kingston, RI, Oct. 9-11, 1998, Guidebook to Field Trips in Rhode Island and adjacent regions of Connecticut and Massachusetts Trip A4, p. A4-1-A4-16.

Wintsch, R.P., Aleinikoff, J.N., Scott, R.B., Walsh, G.J., Yacob, E.Y., and Stone, J.R., 2004, SHRIMP geochronology of detrital zircons from metasedimentary rocks in south-central Connecticut; Preliminary interpretations of the tectonic evolution of the Avalon terrane of southern New England [abs.]: Geological Society of America Abstracts with Programs, v. 36, no. 2, p. 130.

Wintsch, R.P., Aleinikoff, J.N., Walsh, G.J., Bothner, W.A., Hussey, A.M., and Fanning, C.M., 2007, SHRIMP U-Pb evidence for a Late Silurian age of metasedimentary rocks in the Merrimack and Putnam-Nashoba terranes, eastern New England: American Journal of Science, v. 307, no. 1, p. 119–167.

Wintsch, R.P., Kunk, M.J., and Aleinikoff, J.N, Roden-Tice, Mary, Stokes, M.R., Stewart, E.M., and Steinen, R.P., 2012, Temperature-time paths tie the tales of two forelands: The Narragansett and Hartford Basins, *in* Thomas, M.A., (ed.) Geological Society of America, Northeast Section 47th Annual Meeting, Hartford, Connecticut, March 17-20, 2012, Guidebook to Field Trips in Connecticut and Massachusetts Trip C, p. C1-C32.

Soils Appendix

For natural resource information, please contact:

The Environmental & Geographic Information Center
Connecticut Department of Environmental Protection
79 Elm Street
Hartford, CT 06106
(860) 424-3540

For soil survey information, assistance in technical problems, and other natural resources conservation programs, contact:

USDA, Natural Resources Conservation Service
344 Merrow Road, Suite A, Tolland, CT 06084
(860) 871-4011
www.ct.nrcs.usda.gov

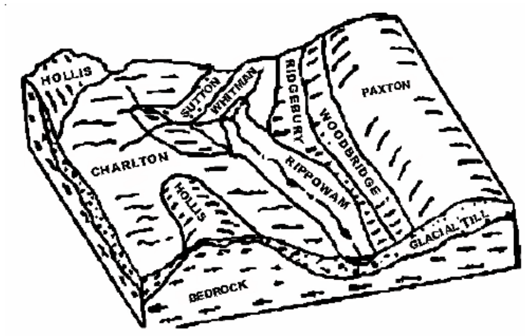
CT DEP-EGIC and USDA-NRCS 2006 Soil Catenas of Connecticut. The Environmental & Geographic Information Center Connecticut Department of Environmental Protection and United States Department of Agriculture, Natural Resources Conservation Service, Tolland, CT.

NRCS
Natural Resources
Conservation Service

USDA is an equal opportunity provider and employer.

Soil Catenas of Connecticut

The relationships between soils, landscapes, geology, and parent material



Connecticut Department of Environmental Protection
and
U.S. Department of Agriculture
Natural Resources Conservation Service

2006

Soil Catenas of Connecticut

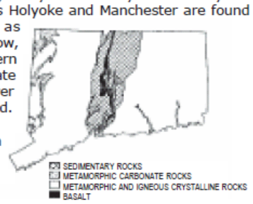
The relationships between soils, landscapes, geology, and parent material

There are 104 major types of soils in Connecticut identified and named. Each type, or series, is named for the geographical area where it was first described. Each soil series has specific relationships to landscapes, regional geology, and parent materials. Related soils of about the same age, derived from similar parent material and occurring under similar climatic conditions, can be arranged into a sequence of increasing wetness. This sequence is called a soil catena.

The soil series of Connecticut have been arranged into the soil catena chart in this brochure. Each horizontal line in the chart represents an individual soil catena and each catena is in turn arranged vertically by differences in surficial deposits, lithology, and soil texture. There are 9 very-poorly drained soil series formed in organic deposits. These have been organized differently at the bottom of the chart.

Since the publication of the soil surveys for all Connecticut counties, the classification of soils has come to be based upon a different classification system that is continuing to evolve. When using the published soil surveys, one will encounter a variety of soil series names that are not currently in use. These series are noted at the bottom of the chart and are referenced by number to the most current name available at the time of this publication. For example, the soil mapped as Acton, if classified by today's standards, may be named Sutton.

The figure below is a simplied bedrock geological map of Connecticut. This map illustrates the regional distribution of bedrock types across the state. It can also be used to determine where a particular soil series may occur. For example, the central portion of Connecticut is a low-lying valley underlain by sedimentary red sandstones and shales. Soil series such as Holyoke and Manchester are found exclusively here. Similarly, soils such as Stockbridge and Nellis occur only in the narrow, limestone valleys located along the western border of the state. The remainder of the state is underlain by acidic gneisses and schists over which most of Connecticut's soils have formed.



The USDA-Natural Resources Conservation Service (formerly Soil Conservation Service) is the lead agency responsible for maintaining soil surveys developed through the National Cooperative Soil Survey Program. Soil survey information information has been updated throughout Connecticut as part of a multi-year project that began in 1991. Field work was completed in 2002. The final product is a statewide survey, with a single legend, at a scale of 1:12,000. The new soils information replaces the older published surveys for each orf the eight counties in Connecticut. These survey books were completed over a 35-year period. Since the eight county surveys were independent surveys and are of different vintages, they each differ in some respects. These county-based soil surveys should be used for historic use only. Official digital soil survey information is available via the Web Soil Survey or Soil Data Mart (http://soils.usda.gov), or by contacting the Connecticut State Soil Scientist at (860) 871-4011.

Soils information must be updated to reflect land use changes and current quality control standards. The new information is adjusted to orthography (true scale photographic base maps) and converted to digital form for use with Geographic Information systems (GIS) and automated drafting software.

Each soil survey report contains detailed descriptions of the soil series, interpretive tables which can be used to determine the best use and management of the land, a collection of soil maps, and a description of the units displayed on the maps. The scale of the maps and the complexity of the terrain determine the types of soil map units used. A map unit in a simple landscape may be composed primarily of a single soil series and is then named for that series. Soil complexes and undifferentiated soil groups are mapped in areas with more intricate mosaics of soils and landscapes. An example of a soil complex is the Nellis-Farmington map unit. An example of an undifferentiated group is the Paxton and Montauk map unit. Portions of the landscape that do not have true soil or contain little or no soil are mapped as miscellaneous areas. Examples include urban land, beaches, and rock outcrops. Subdivisions of the soil series that are significant to land use and management are called phases. Soil phases reflect differences such as surface stoniness, slope gradient, surface texture, and rockiness. Examples of these are very stony, 3 to 8 percent slope, fine sandy loam, and very rocky soil phases, respectively. Within most map units are *minor components*, or small areas of soils that differ significantly from the named *major component* soils. Minor components are typically too small to be delineated separately.

The purpose of the chart in this brochure is to diagram the inter-relationships of the soils of Connecticut. This chart supplements all Connecticut soil surveys by referring to both current and previously used soil names. However, since there are some major differences in map units and soil series interpretations from survey to survey, it is necessary to refer to the narrative descriptions within the appropriate survey to obtain complete information concerning a particular soil.

SOIL CATENAS OF CONNECTICUT

DEPOSIT	LITHOLOGY	TEXTURE GROUP	DRAINAGE CLASS: EXCESSIVELY	SOMEWHAT EXCESSIVELY	WELL	MODERATELY WELL	SOMEWHAT POORLY	POORLY	VERY POORLY
GLACIAL TILL Unstratified Sand, Silt & Rock	GRANITE & SCHIST	SANDY		GLOUCESTER * WESTMINSTER #					
	SCHIST, GRANITE & GNEISS	LOAMY		* HOLLIS [28]	** MILLSITE # ** CHATFIELD CHARLTON CANTON BICE # + PAXTON + MONTAUK + SHELBURNE #	SUTTON [1] SCHROON # + WOODBRIDGE + ASHFIELD #		LEICESTER + RIDGEBURY	LOONMEADOW # + WHITMAN
	MIXED LIMESTONE & CRYSTALLINE ROCKS	LOAMY			*FARMINGTON PYRITIES # STOCKBRIDGE NELLIS [11]	+ HOGANSBURG # GEORGIA AMENIA		MUDGEPOND [18, 20]	ALDEN [19]
	RED SANDSTONE, SHALE, CONGLOMERATE & BASALT	LOAMY			* HOLYOKE [29] ** YALESVILLE CHESHIRE [24, 29] + WETHERSFIELD	WATCHAUG [6] + LUDLOW		+ WILBRAHAM	+ MENLO
	BROWN MICACEOUS SCHIST	LOAMY		* BRIMFIELD	BROOKFIELD				
	PHYLLITE, SCHIST & SLATE	LOAMY		* TACONIC #	** MACOMBER # + BERNARDSTON + LANESBORO # DUMMERSTON #	+ FULLAM #		+ BRAYTON #	
	SHALE, SANDSTONE, BASALT & CRYSTALLINE ROCKS	SILTY / SANDY			+ BROADBROOK [24] NARRAGANSETT	+ RAINBOW WAPPING			
GLACIOFLUVIAL Stratified Sand & Gravel	ACIDIC CRYSTALLINE ROCKS	SANDY & GRAVELLY	HINCKLEY [17] BOSCAWEN #	MERRIMAC		SUDBURY		WALPOLE [3] MOOSILAUKE #	
		SANDY	WINDSOR			DEERFIELD			SCARBORO [15, 32]
		LOAMY / SAND & GRAVEL			AGAWAM	NINIGRET			
		SILTY / SAND & GRAVEL			ENFIELD [16] HAVEN BRANFORD	TISBURY ELLINGTON		RAYPOL	
	ACIDIC, RED SANDSTONE, SHALE, CONGLOMERATE	SANDY & GRAVELLY	MANCHESTER	HARTFORD					
		SANDY	PENWOOD						
	MIXED LIMESTONE & CRYSTALLINE ROCKS	SANDY & GRAVELLY	GROTON						
		LOAMY / SAND & GRAVEL			COPAKE	HERO		FREDON	HALSEY [7]
GLACIOLACUSTRINE Stratified Sand Silt & Clay	MIXED CRYSTALLINE & SEDIMENTARY ROCKS	SILTY				BELGRADE [27]		RAYNHAM [31]	
		LOAMY / CLAYEY				ELMRIDGE [13, 21]		SHAKER [30]	
		SILTY & CLAYEY				BRANCROFT [9] BERLIN		SCITICO [26]	MAYBID [5,33]
ALLUVIAL Stratified Sand & Silt	GNEISS, SCHIST, GRANITE & QUARTZITE	SANDY	SUNCOOK						
		LOAMY			ONDAWA # OCCUM [4]	POOTATUCK [23]		RUMNEY # RIPPOWAM	
	MIXED CRYSTALLINE & SEDIMENTARY ROCKS	SILTY			HADLEY [14]	WINOOSKI [12]	BASH [8, 25]	LIMERICK LIM	MEDOMAK # SACO

	WETLAND TYPE	FIBERS	THICKNESS	SUBSTRATE	SOIL SERIES
ORGANIC Peat & Muck	FRESH (INLAND)	FEW	>51"	VARIABLE	CATDEN [10]
					FREETOWN
					BUCKSPORT #
			16-51"	LOAMY	NATCHAUG [22]
				LOAMY	WONSQUEAK #
	SALT & BRACKISH (TIDAL)	COMMON	16-51"	SANDY	TIMAKWA [2]
					PAWCATUCK
				VARIABLE	WESTBROOK
			>51"		IPSWICH

+ Indicates soils underlain by compact till.
* Indicates shallow soils less than 20 inches to bedrock.
** Indicates moderately deep soils 20 to 40 inches to bedrock.
# Indicates soils with mean annual soil temperature less than 8°C (>1,300 feet in Litchfield County).

SOIL SERIES NO LONGER USED IN CONNECTICUT

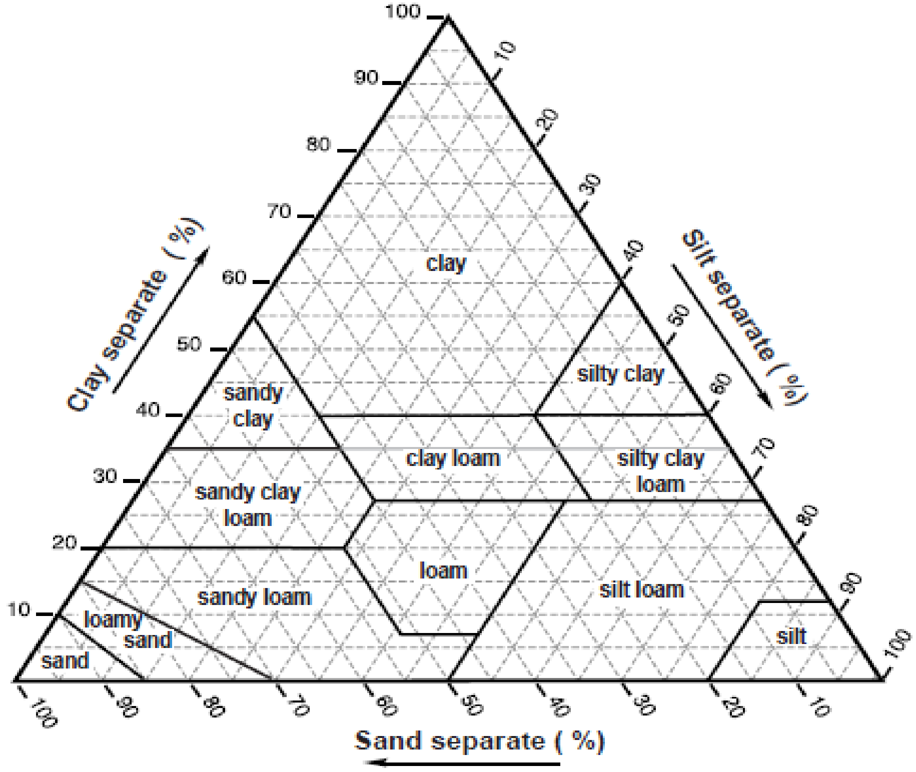
1. Acton
2. Adrian
3. Au Gres
4. Bermudian
5. Biddeford
6. Birchwood
7. Birdsall
8. Bowmansville
9. Buxton
10. Carlisle
11. Dover
12. Eel
13. Elmwood
14. Genesse
15. Granby
16. Hartland
17. Jaffrey
18. Kendaia
19. Lyons
20. Massena
21. Melrose
22. Palms
23. Podunk
24. Poquonock
25. Rowland
26. Scantic
27. Scio
28. Shapleigh
29. Sunderland
30. Swanton
31. Wallington
32. Wareham
33. Whately

Connecticut Department of Environmental Protection and USDA, Natural Resources Conservation Service

January 2006

Texture Triangle:

Fine Earth Texture Classes (▬▬▬)



TEXTURE MODIFIERS - Conventions for using "Rock Fragment Texture Modifiers" and for using textural adjectives that convey the "% volume" ranges for **Rock Fragments - Size and Quantity**.

Fragment Content % By Volume	Rock Fragment Modifier Usage
< 15	No texture adjective is used (noun only; e.g., *loam*).
15 to < 35	Use adjective for appropriate size; e.g., *gravelly*.
35 to < 60	Use "very" with the appropriate size adjective; e.g., *very gravelly*.
60 to < 90	Use "extremely" with the appropriate size adjective; e.g., *extremely gravelly*.
≥ 90	No adjective or modifier. If ≤ 10% fine earth, use the appropriate noun for the dominant size class; e.g., *gravel*. Use **Terms in Lieu of Texture**.

WOODBRIDGE SERIES (CT MA NH NY RI)

The Woodbridge series consists of moderately well drained loamy soils formed in lodgement till. They are very deep to bedrock and moderately deep to a densic contact. They are nearly level through moderately steep soils on till plains, hills, and drumlins. Slope ranges from 0 through 25 percent. Saturated hydraulic conductivity ranges from moderately low or moderately high in the surface layer and subsoil and low or moderately low in the dense substratum. Mean annual temperature is about 9 degrees C., and mean annual precipitation is about 1168 millimeters.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Aquic Dystrudepts

TYPICAL PEDON: Woodbridge fine sandy loam - grass field, at an elevation of about 177 meters. (Colors are for moist soil unless otherwise noted.)

Ap-- 0 to 7 inches (0 to 18 centimeters); very dark grayish brown (10YR 3/2) fine sandy loam, light brownish gray (10YR 6/2) dry; moderate medium granular structure; friable; many fine and medium roots; few very dark brown (10YR 2/2) earthworm casts; 5 percent gravel; moderately acid; abrupt wavy boundary. (4 to 12 inches (10 to 30 centimeters) thick.)

Bw1-- 7 to 18 inches (18 to 46 centimeters); dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine roots; few very dark brown (10YR 2/2) earthworm casts; 10 percent gravel; moderately acid; gradual wavy boundary.

Bw2-- 18 to 26 inches (46 to 66 centimeters); dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine roots; few very dark brown (10YR 2/2) earthworm casts; 10 percent gravel; few medium prominent strong brown (7.5YR 5/6) masses of iron accumulation and light brownish gray (10YR 6/2) areas of iron depletion; moderately acid; gradual wavy boundary.

Bw3-- 26 to 30 inches (66 to 76 centimeters); light olive brown (2.5Y 5/4) fine sandy loam; weak medium subangular blocky structure; friable; few fine roots; 10 percent gravel; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation and light brownish gray (10YR 6/2) areas of iron depletion; moderately acid; clear wavy boundary. (Combined thickness of the Bw horizons is 12 to 37 inches (31 to 94 centimeters).)

Cd1-- 30 to 43 inches (76 to 109 centimeters); light olive brown (2.5Y 5/4) gravelly fine sandy loam; weak thick platy structure; very firm, brittle; 20 percent gravel; many medium prominent strong brown (7.5YR 5/8) masses of iron accumulation and light brownish gray (10YR 6/2) areas of iron depletion; moderately acid; gradual wavy boundary.

Cd2-- 43 to 65 inches (109 to 165 centimeters); light olive brown (2.5Y 5/4) gravelly fine sandy loam; weak thick platy structure; very firm, brittle; few fine prominent very dark brown (10YR 2/2) coatings on plates; 25 percent gravel; common fine prominent strong brown (7.5YR 5/8) masses of iron accumulation; moderately acid.

TYPE LOCATION: Tolland County, Connecticut; town of Mansfield, 0.75 mile south of the intersection of Connecticut Routes 275 and 195, and 0.25 mile east on the University of Connecticut Agronomy Farm, 800 feet north of the greenhouses near the corner of a brushy field. USGS Spring Hill, CT topographic quadrangle, Latitude 41 degrees, 47 minutes, 53 seconds N., Longitude 72 degrees, 13 minutes, 48 seconds W., NAD 1927.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 46 through 100 centimeters. Depth to densic materials commonly is 50 through 100 centimeters but the range currently includes 46 through 100 centimeters. Depth to bedrock is commonly more than 2 meters. Rock fragments commonly range from 0 through 34 percent. Except where the surface is stony, the fragments are mostly subrounded gravel and typically make up 60 percent or more of the total rock fragments. Unless limed, reaction ranges from very strongly acid through slightly acid.

Some pedons have an O horizon.

The Ap horizon has hue of 10YR, value of 3 or 4, and chroma of 2 through 4. Dry value is 6 or more. Undisturbed pedons have a thin A horizon with hue of 7.5YR or 10YR, value of 2 or 3 and chroma of 1 or 2. The Ap or A horizon is loam, fine sandy loam, or sandy loam in the fine-earth fraction.

Some pedons have a thin E horizon below the A horizon. It has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 through 3.

The upper part of the Bw horizon has hue of 7.5YR through 2.5Y, value of 3 through 6, and chroma of 3 through 8. The lower part of the Bw horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 3 through 6. Iron depletions are within 60 centimeters. The Bw horizon is loam, fine sandy loam, or sandy loam with less than 65 percent silt plus very fine sand.

Some pedons have a thin BC horizon.

Some pedons have an E or E' horizon up to 3 inches thick below the B horizon. It has hue of 10YR through 5Y, value of 5 or 6, chroma of 2 or 3, and has redoximorphic features. Typically, it is coarser-textured than the overlying horizon.

Some pedons have a C horizon above the Cd horizon.

The Cd horizon has hue of 10YR through 5Y, value of 4 through 6, and chroma of 1 through 4. It commonly has redoximorphic features. Texture is loam, fine sandy loam, sandy loam, or coarse sandy loam in the fine-earth fraction. The structure is not pedogenetically derived, and appears in the form of medium to very thick plates, or it is massive. Consistence is firm or very firm.

COMPETING SERIES: These are the Chautauqua, Pittstown, Pompton, Rainbow, Sutton, Wapping, and Wilbraham series. Chautauqua, Pompton, Sutton, and Wapping soils do not have a dense substratum. Pittstown and Rainbow soils have more than 65 percent silt plus very fine sand in the solum. Wilbraham soils are wetter and have iron depletions throughout the B horizon.

GEOGRAPHIC SETTING: Woodbridge soils are nearly level to moderately steep and are on till plains, hills and drumlins. Slope commonly is less than 8 percent, but the range includes 0 through 25 percent. The soils formed in acid till derived mostly from schist, gneiss, and granite. Mean annual temperature ranges from 45 through 52 degrees F., mean annual precipitation ranges from 37 through 49 inches, and the growing season ranges from 115 through 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Rainbow, Sutton, and Wapping soils and the Bernardston, Broadbrook, Canton, Charlton, Chatfield, Georgia, Hollis, Leicester, Montauk, Paxton, Ridgebury, Scituate, and Whitman soils on nearby landscapes. The well drained Paxton, somewhat poorly and poorly drained Ridgebury, and the very poorly drained Whitman soils are associated in a drainage sequence. Bernardston and Broadbrook soils are well drained and are finer textured. Canton and Charlton soils are well drained and do not have a dense substratum. Chatfield and Hollis soils have bedrock within depths of 20 to 40 and 10 to 20 inches respectively. Georgia soils are calcareous within 80 inches. Leicester soils are poorly drained and do not have a dense substratum. Montauk soils are well drained and are coarser textured. Scituate soils have a loamy sand substratum.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. The potential for surface runoff is moderate to very high. Saturated hydraulic conductivity ranges from moderately low or moderately high in the surface layer and subsoil and low or moderately low in the dense substratum.

USE AND VEGETATION: Many areas are cleared and used for cultivated crops, hay, or pasture. Scattered areas are used for community development. Some areas are wooded. Common trees are red, white, and black oak, hickory, white ash, sugar maple, red maple, eastern hemlock, and eastern white pine.

DISTRIBUTION AND EXTENT: Glaciated uplands of Connecticut, Massachusetts, New Hampshire, eastern New York, and Rhode Island. MLRAs 144A, 145, and 149B. The series is of large extent.

SERIES ESTABLISHED: Essex County, Massachusetts, 1925.

REMARKS: This revision reflects changes to the range in characteristics as well as general updating to metric units. Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils. Historically, Woodbridge soils have been previously classified as Aquic Dystrochrepts and before that as Typic Fragiochrepts.

Woodbridge soils were previously used in Maine. Soil temperature studies in Maine have resulted in the use of the frigid soil temperature regime for soils in areas formerly identified as mesic.

Diagnostic horizons and features recognized in this pedon are:
1. Ochric epipedon - the zone from 0 to 7 inches (0 to 18 centimeters) (Ap horizon).
2. Cambic horizon - the zone from 7 to 30 inches (18 to 76 centimeters) (Bw horizons).
3. Aquic feature - low chroma areas of iron depletion within 60 centimeters (Bw2 horizon).
4. Densic materials - the zone from 30 to 65 inches (76 to 165 centimeters) (Cd1 and Cd2 horizons).
5) Particle-size control section - the zone from 18 to 76 centimeters (Bw horizons).

ADDITIONAL DATA: Characterization data for sample no. 56NH017003, 58NH019001, 58CT013004, 95NH013002, 96NH013006, 00CT013003. Pedons analyzed by the NSSL, Lincoln, NE.

National Cooperative Soil Survey U.S.A.

CHARLTON SERIES (CT+MA NH NY RI)

The Charlton series consists of very deep, well drained loamy soils formed in till derived from parent materials that are very low in iron sulfides. They are nearly level to very steep soils on till plains and hills. Slope ranges from 0 to 50 percent. Saturated hydraulic conductivity is moderately high or high. Mean annual temperature is about 10 degrees C and mean annual precipitation is about 1194 millimeters.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Typic Dystrudepts

TYPICAL PEDON: Charlton fine sandy loam - forested, very stony, at an elevation of about 170 meters. (Colors are for moist soil.)

Oe -- 0 to 2.5 centimeters; black (10YR 2/1) moderately decomposed forest plant material. (0 to 5 centimeters thick.)

A -- 2.5 to 10 centimeters; dark brown (10YR 3/3) fine sandy loam; weak fine granular structure; very friable; many fine roots; 5 percent gravel; very strongly acid; abrupt smooth boundary. (2.5 to 15 centimeters thick.)

Bw1 -- 10 to 18 centimeters; brown (7.5YR 4/4) fine sandy loam; weak coarse granular structure; very friable; many fine and medium roots; 5 percent gravel; very strongly acid; clear wavy boundary.

Bw2 -- 18 to 48 centimeters; yellowish brown (10YR 5/6) fine sandy loam; weak medium subangular blocky structure; very friable; common fine and medium roots; 10 percent gravel and cobbles; very strongly acid; clear wavy boundary.

Bw3 -- 48 to 68.5 inches; light olive brown (2.5Y 5/4) gravelly fine sandy loam; massive; very friable; few medium roots; 15 percent gravel and cobbles; very strongly acid; abrupt wavy boundary. (Combined thickness of the Bw horizons is 35.5 to 91 centimeters.)

C -- 68.5 to 165 centimeters; grayish brown (2.5Y 5/2) gravelly fine sandy loam with thin lenses of loamy sand; massive; friable, some lenses firm; few medium roots; 25 percent gravel and cobbles; strongly acid.

TYPE LOCATION: New Haven County, Connecticut; town of Middlebury, 3800 feet along Long Meadow Road from the intersection with South Street, 450 feet southeast along a gravel road and 50 feet west of the gravel road, 400 feet northeast of Long Meadow Pond, in a wooded area. USGS Naugatuck topographic quadrangle, Latitude 41 degrees 29 minutes 50 seconds N., Longitude 73 degrees 6 minutes 31 seconds W., NAD 1927.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 50 to 97 centimeters. Depth to bedrock is commonly more than 180 centimeters. Rock fragments range from 5 to 35 percent by volume to a depth of 100 centimeters and up to 50 percent below 100 centimeters. Except where the surface layer is stony, the fragments are mostly subrounded gravel and typically make up 60 percent or more of the total rock fragments. Unless limed, reaction ranges from very strongly acid to moderately acid. The ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron is high, greater than 0.15.

Some pedons have an O horizon.

The A horizon has hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 to 3. Disturbed pedons have an Ap horizon with value of 3 or 4 and chroma of 2 to 4. The A or Ap horizon is sandy loam, fine sandy loam, or loam in the fine-earth fraction. It has weak or moderate granular structure and is friable or very friable.

Some pedons have a thin E horizon below the A horizon. It has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 3. Texture, structure, and consistence are like the A horizon.

The upper part of the Bw horizon has commonly hue of 7.5YR or 10YR, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (> 0.15) exists, and value and chroma of 4 to 6. The lower part of the Bw horizon has hue of 10YR or 2.5Y and value and chroma of 4 to 6. Texture of the Bw horizon is loam, fine sandy loam, or sandy loam with less than 65 percent silt plus very fine sand in the fine earth fraction. It has weak granular or subangular blocky structure. Consistence is friable or very friable.

Some pedons have a BC horizon with value and chroma like the lower part of the Bw horizon, but includes hue of 5Y. The BC horizon commonly has texture, structure, and consistence like the Bw horizon but the range includes non-pedogenetically derived structure appearing in the form of thin plates.

The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 2 to 6. Texture is loam, fine sandy loam, or sandy loam in the fine-earth fraction, with pockets or thin lenses of loamy sand. The horizon is massive or is non-pedogenetically derived, appearing in the form of thin plates. Consistence commonly is very friable or friable but in some pedons includes firm.

COMPETING SERIES: These are the Ashe, Buladean, Cardigan, Chestnut, Delaware, Dutchess, Edneyville, Foresthills (T), Gallimore, Greenbelt (T), Hazel, Lordstown, Riverhead, Rixeyville (T), Soco, St. Albans, Stecoah, Steinsburg, and Yalesville series. Ashe, Buladean, Chestnut, Edneyville, Gallimore, Soco, and Stecoah soils are from outside LRR R & S. Ashe, Buladean, and Hazel soils formed in residuum. Cardigan soils formed in till derived from phyllite or slate. Cardigan, Chestnut, Lordstown, Rixeyville (T), Steinsburg, and Yalesville soils are moderately deep to bedrock. Delaware soils are derived from alluvium and have less than 5 percent rock fragments in the lower sola and substratum. Rock fragments in the Dutchess soil are dominantly phyllite, slate, or shale. Edneyville soils formed in residuum and have a C horizon of saprolite. Gallimore soils have a cambic horizon that is more than 127 cm deep. Foresthills (T) and Greenbelt (T) soils are anthropogenic soils, contain buried horizons and have mantles of human transported materials. Riverhead soils are stratified in the substratum. Soco and Stecoah soils formed in residuum derived from sedimentary rocks. St. Albans soils have less silt and very fine sand.

GEOGRAPHIC SETTING: Charlton soils are nearly level to very steep soils on till plains and hills. Slope ranges from 0 to 50 percent. The soils formed in acid till derived from parent materials that are very low in sulfur, mainly from schist, gneiss, or granite. Mean annual temperature ranges from 7 to 11 degrees C and mean annual precipitation commonly ranges from 940 to 1245 centimeters, but the range includes as low as 660 centimeters in some places east of Adirondack Mountains in the Champlain Valley of New York. The growing season ranges from 115 to 185 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Acton, Brookfield, Chatfield, Essex, Hollis, Leicester, Rainbow, Ridgebury, Sutton, Wapping, Whitman, and Woodbridge soils on nearby landscapes. The moderately well drained Sutton and the poorly drained Leicester soils are associated in a drainage sequence. Acton and Wapping soils are moderately well drained. Brookfield soils formed in iron sulfide bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Chatfield soils have bed rock within a depth of 50 to 100 centimeters. Essex soils have a sandy particle-size control section and a dense substratum. Hollis soils have bedrock within a depth of 25 to 50 centimeters. Rainbow and Woodbridge soils are moderately well drained with a dense substratum. Ridgebury soils are poorly drained and have a dense substratum. Whitman soils are very poorly drained with a dense substratum.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff is negligible to medium. Saturated hydraulic conductivity is moderately high or high in the mineral soil.

USE AND VEGETATION: Areas cleared of stones are used for cultivated crops, specialty crops, hay, and pasture. Many scattered areas are used for community development. Stony areas are mostly wooded. Common trees are northern red, white, and black oak, hickory, sugar maple, red maple, black and gray birch, white ash, beech, white pine, and hemlock.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island. MLRAs 142,144A, and 145. The series is of large extent.

SERIES ESTABLISHED: Worcester County, Massachusetts, 1922.

REMARKS: This revision reflects revision of the series concept and range in characteristics as well as general updating to metric units. Research results indicate Charlton soils are not associated with iron sulfide bearing materials. The ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron is high, greater than 0.15. These characteristics provide a distinction from other series, particularly the Brookfield series.
Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 to 10 centimeters (Oe & A horizon).
2. Cambic horizon - the zone from 10 to 68.5 centimeters (Bw1, Bw2, and Bw3 horizons).
3. Particle-size class - coarse-loamy in the control section from 25 to 100 centimeters.

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006. Full characterization data for sample no. S99NY005001. Pedon analyzed by the NSSL, Lincoln, NE.

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HINCKLEY SERIES (MA CT NJ NH NY RI VT)

The Hinckley series consists of very deep, excessively drained soils formed in glaciofluvial materials. They are nearly level through very steep soils on terraces, outwash plains, deltas, kames, and eskers. Saturated hydraulic conductivity is high or very high. Slope ranges from 0 through 60 percent. Mean annual temperature is about 45 degrees F. (7 degrees C.) and mean annual precipitation is about 45 inches (1143 millimeters).

TAXONOMIC CLASS: Sandy-skeletal, mixed, mesic Typic Udorthents

TYPICAL PEDON: Hinckley loamy sand in woodland at an elevation of about 785 feet. (All colors are for moist soil.)

Oe-- 0 to 1 inch (0 to 3 centimeters); moderately decomposed plant material derived from red pine needles and twigs. (0 to 2 inches (0 to 5 centimeters) thick.)

Ap-- 1 to 8 inches (3 to 20 centimeters); very dark grayish brown (10YR 3/2) loamy sand; weak fine and medium granular structure; very friable; many fine and medium roots; 5 percent fine gravel; very strongly acid; abrupt smooth boundary. (1 to 10 inches (3 to 25 centimeters) thick.)

Bw1-- 8 to 11 inches (20 to 28 centimeters); strong brown (7.5YR 5/6) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 20 percent gravel; very strongly acid; clear smooth boundary.

Bw2-- 11 to 16 inches (28 to 41 centimeters); yellowish brown (10YR 5/4) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 25 percent gravel; very strongly acid; clear irregular boundary. (Combined thickness of the Bw horizon is 3 to 16 inches (8 to 41 centimeters).)

BC-- 16 to 19 inches (41 to 48 centimeters); yellowish brown (10YR 5/4) very gravelly sand; single grain; loose; common fine and medium roots; 40 percent gravel; strongly acid; clear smooth boundary. (0 to 5 inches, 0 to 13 centimeters thick)

C-- 19 to 65 inches (48 to 165 centimeters); light olive brown (2.5Y 5/4) extremely gravelly sand consisting of stratified sand, gravel and cobbles; single grain; loose; common fine and medium roots in the upper 8 inches (20 centimeters) and very few below; 60 percent gravel and cobbles; moderately acid.

TYPE LOCATION: Worcester County, Massachusetts; Town of Petersham, Harvard Forest, 240 feet north of Tom Swamp Road at a point 1.15 miles east of the intersection of Athol Road and Tom Swamp Road. USGS Athol, MA topographic quadrangle, Latitude 42 degrees, 30 minutes, 41.8 seconds N., and Longitude 72 degrees, 12 minutes, 28.9 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 12 through 34 inches (30 through 87 centimeters). Rock fragment content of the solum ranges from 5 through 50 percent gravel, 0 through 30 percent cobbles, and 0 through 3 percent stones. Rock fragment content of individual horizons of the substratum ranges from 10 through 55 percent gravel, 5 through 25 percent cobbles, and 0 through 5 percent stones. In some places gravel content throughout the soil ranges up through 75 percent. The soil ranges from extremely acid through moderately acid, except where limed.

The O horizon where present has hue N or 2.5YR through 7.5YR, value of 2 or 3, and chroma of 0 through 3. They are fibric, hemic, or sapric material.

The Ap horizon has hue of 7.5YR or 10YR, value of 2 through 4, and chroma of 1 through 4. Texture of the fine-earth fraction is very fine sandy loam, fine sandy loam, sandy loam, loamy fine sand, loamy sand, or loamy coarse sand. Structure is weak or moderate very fine through coarse granular or subangular blocky. Consistence is friable or very friable. Undisturbed areas have an A horizon that has hue of 10YR, value of 2, and chroma of 1 through 4.

Some pedons have thin E, Bhs, Bh, or Bs horizons below the A horizon.

The upper part of the Bw horizon has hue of 7.5YR or 10YR, value of 3 through 5, and chroma of 3 through 8. The lower part has hue of 7.5YR through 2.5Y, value of 3 through 6, and chroma of 3 through 8. Texture, to a depth of 10 inches (25 centimeters) from the surface, is fine sandy loam, sandy loam, loamy fine sand, loamy sand, or loamy coarse sand in the fine-earth fraction. Below 10 inches (25 centimeters) it is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand, or coarse sand in the fine-earth fraction. Structure commonly is weak fine and/or medium granular or the horizon is structureless, but ranges through weak subangular blocky in some places. It is very friable, friable, or loose.

Some pedons have a BC horizon with characteristics similar to both the B and 2C horizons.

The C horizon has hue of 7.5YR through 5Y, value of 3 through 7, and chroma of 2 through 8. Texture is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand or coarse sand in the fine-earth fraction, and is stratified.

COMPETING SERIES: These are the Bonaparte, Manchester, Mecosta, Multorpor, Otisville, Quonset, and Rikers series. Mecosta and Multorpor soils are from outside Land Resource Region R. Bonaparte soils have carbonates within a depth of 40 inches. Manchester soils have 5YR or redder hue in the Bw and C horizons. Mecosta soils are calcareous and Multorpor soils do not have Bw horizons. Otisville soils have rock fragments dominated by sandstone, shale, and slate. Quonset soils have rock fragments dominated by phyllite, slate, and shale. Rikers soils have carboliths in the soil.

GEOGRAPHIC SETTING: Hinckley soils are nearly level through very steep soils on terraces, outwash plains, deltas, kames, and eskers. Slope is generally 0 through 8 percent on tops of the terraces, outwash plains and deltas. Slope of 8 through 60 percent or more are on the kames, eskers and margins of the outwash plains, deltas, and terraces. The soils formed in glaciofluvial sand and gravel derived principally from granite, gneiss, and schist. Mean annual temperature ranges from 45 through 55 degrees F. (7 through 13 degrees C.) and mean annual rainfall ranges from 40 through 50 inches (1016 through 1270 millimeters). Length of the growing season ranges from 140 through 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Canton, Charlton, Deerfield, Essex, Gloucester, Horseneck, Mashpee (T), Massasoit (T), Merrimac, Paxton, Pompton, Riverhead, Scarboro, Sudbury, Walpole, Wareham, and Windsor soils on nearby landscapes. Horseneck, Pompton, and Riverhead soils are commonly associates in the extreme southern portions of MLRA 144A. Agawam, Merrimac, and Riverhead soils are similar to Hinckley soils, but have Cambic horizons. Canton, Charlton, Essex, Gloucester, and Paxton soils formed in till. Deerfield, Horseneck, and Sudbury soils are moderately well drained and Horseneck and Sudbury soils have Cambic horizons. Pompton soils have Cambic horizons and are moderately well and somewhat poorly drained. Scarboro soils are very poorly drained. Windsor soils have less than 15 percent rock fragments. Mashpee (T) and Massasoit (T) soils are poorly drained with spodic horizons. Walpole and Wareham soils are poorly drained.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Excessively drained. Surface runoff is negligible through low. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Cleared areas are used for hay, pasture, and silage corn. In the southern Connecticut River Valley, Hinckley soils are used for growing tobacco and truck crops and in eastern Massachusetts, truck crops. Most areas are forested, brush land or used as urban land. Northern red, black, white, scarlet and scrub oak, eastern white and pitch pine, eastern hemlock, and gray birch are the common trees. Unimproved pasture and idle land support hardhack, little bluestem, bracken fern, sweet fern, and low bush blueberry.

DISTRIBUTION AND EXTENT: Connecticut, Massachusetts, northern New Jersey, New Hampshire, New York, Rhode Island, and Vermont. MLRA's 101, 141, 142, 144A, 145, and 149B. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Oneida County, New York, 1913.

REMARKS: The use of the Hinckley series in Maine, and in MLRA 143 and 144B, is relict to before temperature classes. These have been removed from the SC file.

Diagnostic horizons and features recognized in this pedon are:
1. Ochric epipedon - the zone from 1 to 8 inches (3 to 20 centimeters) (Ap horizon).
2. Sandy-skeletal feature - the from 10 to 40 inches (25 to 100 centimeters) has a weighted average content of rock fragments of 51 percent and a particle size of the fine-earth fraction is sandy (Bw, BC, and C horizons).

ADDITIONAL DATA: Reference samples from pedons S55NH015002, S56MA011002, S56MA011003, S57MA023005, S58NH015002, S73MA009001, S73MA005002, S73MA009004, S73MA005005, S96NH013003 from Massachusetts and New Hampshire, samples by NSSL, Lincoln, NE, various dates

National Cooperative Soil Survey U.S.A.

PAXTON SERIES **(**CT MA NH NY RI VT)

The Paxton series consists of well drained loamy soils formed in lodgement till. The soils are very deep to bedrock and moderately deep to a densic contact. They are nearly level to steep soils on till plains, hills, and drumlins. Slope ranges from 0 to 45 percent. Saturated hydraulic conductivity is moderately high or high in the surface layer and subsoil and low to moderately high in the substratum. Mean annual temperature is about 10 degrees C., and mean annual precipitation is about 1194 millimeters.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Oxyaquic Dystrudepts

TYPICAL PEDON: Paxton fine sandy loam - in a brushy field at an elevation of about 850 feet. (Colors are for moist soil unless otherwise noted.)

Ap-- 0 to 8 inches (0 to 20 centimeters); dark brown (10YR 3/3) fine sandy loam, pale brown (10YR 6/3) dry; moderate medium granular structure; friable; many fine roots; 5 percent gravel; strongly acid; abrupt smooth boundary. (5 to 11 inches (13 to 28 centimeters) thick.)

Bw1-- 8 to 15 inches (20 to 38 centimeters); dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine roots; 5 percent gravel; few earthworm casts; strongly acid; gradual wavy boundary.

Bw2-- 15 to 26 inches (38 to 66 centimeters), olive brown (2.5Y 4/4) fine sandy loam; weak medium subangular blocky structure; friable; few fine roots; 10 percent gravel; strongly acid; clear wavy boundary. (Combined thickness of the Bw horizon is 15 to 37 inches (38 to 94 centimeters).)

Cd-- 26 to 65 inches (66 to 165 centimeters); olive (5Y 5/3) gravelly fine sandy loam; moderate thick plates; very firm, brittle; 25 percent gravel; many dark coatings on plates; strongly acid.

TYPE LOCATION: New Haven County, Connecticut; town of Prospect, 0.4 mile east of Straitsville Road and 0.5 mile north of the Bethany - Prospect town line; USGS Mount Carmel, CT topographic quadrangle; Latitude 41 degrees, 28 minutes, 34 seconds N., Longitude 72 degrees, 59 minutes, 16 seconds W., NAD 1927

RANGE IN CHARACTERISTICS: Thickness of the mineral solum commonly ranges from 50 to 100 centimeters. The depth to the densic contact and material is commonly 50 to 100 centimeters, but the range includes 46 to 100 centimeters. Depth to bedrock is commonly more than 1.5 meters. Rock fragments range from 5 through 35 percent by volume in the mineral soil. Except where the surface is stony, the fragments are mostly subrounded gravel and typically make up 60 percent or more of the total rock fragments. Unless limed, reaction ranges from very strongly acid through moderately acid in the mineral soil.

The O horizon, where present, has hue of 5YR through 10YR or it is neutral, value of 2 through 3 and chroma of 0 through 2. It is mainly composed of slightly, moderately, or highly decomposed plant material.

The Ap horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 through 4. Dry value is 6 or more. Undisturbed pedons have a thin A horizon with value of 2 or 3 and chroma of 1 or 2. The Ap or A horizon is loam, fine sandy loam, or sandy loam in the fine-earth fraction.

Some pedons have a thin E horizon below the A horizon. It has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 through 3.

The upper part of the Bw horizon has hue of 7.5YR or 2.5Y, value of 4 through 6, and chroma of 4 through 8. The lower part of the Bw horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 3 through 6. Some pedons have few faint redoximorphic features just above the Cd horizon. The Bw horizon is loam, fine sandy loam, or sandy loam with less than 65 percent silt plus very fine sand. It has granular or subangular blocky structure Consistence is friable or very friable.

Some pedons have a thin BC horizon.

Some pedons have an E or E' horizon up to 3 inches thick below the B horizon. It has hue of 10YR through 5Y, value of 5 or 6, and chroma of 2 or 3. Typically, it is coarser textured than the overlying horizon.

The Cd has hue of 10YR through 5Y, value of 4 through 6, and chroma of 2 through 4. In some pedons there are a few faint or distinct areas of iron depletion or masses of iron accumulation in the upper part. Texture is loam, fine sandy loam, sandy loam, or coarse sandy loam in the fine-earth fraction. A few thin lenses of loamy sand are in some pedons. The structure is geogenetically derived, appearing in the form of medium to very thick plates, or it is massive. Consistence is firm or very firm. Some pedons have a friable C horizon above the Cd horizon.

COMPETING SERIES: The Amostown, Bernardston, Broadbrook, Horseneck, Nantucket, Scituate, and Wethersfield series are currently in the same family. Amostown soils are underlain by stratified very fine sand or silt within a depth of 100 centimeters. Bernardston and Broadbrook soils have a solum with more than 65 percent silt plus very fine sand. Horseneck soils lack a densic contact. Nantucket soils have a lithologic discontinuity. Scituate soils have sandy substrata. Wethersfield soils have 5YR or redder hue in the B and C horizons.

GEOGRAPHIC SETTING: Paxton soils are nearly level to steep and are on till plains, hills, and drumlins. Slope commonly is 0 through 35 percent, but range from 0 through 45 percent in some pedons. The soils formed in acid lodgement till derived mostly from schist, gneiss, and granite. Mean annual temperature ranges from 7 to 11 degrees C., mean annual precipitation ranges from 940 to 1245 millimeters, and the growing season ranges from 115 through 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Bernardston, Broadbrook, and Scituate soils and the Canton, Charlton, Chatfield, Georgia, Hollis, Leicester, Montauk, Narragansett, Pittstown, Ridgebury, Stockbridge, Sutton, Wapping, Whitman, and Woodbridge soils on nearby landscapes. The moderately well drained Woodbridge, poorly drained Ridgebury, and the very poorly drained Whitman soils are associated in a drainage sequence. Canton soils have a friable loamy sand substratum. Well drained Stockbridge and moderately well drained Georgia soils have higher base status. Hollis soils have bedrock within a depth of 10 to 20 inches. Leicester soils are poorly drained and do not have a dense substratum. Montauk soils have sandy substrata. Narragansett soils have a lithologic discontinuity within a depth of 40 inches and a solum high in silt and very fine sand. Sutton and Wapping soils are moderately well drained and do not have a dense substratum.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Surface runoff is negligible to high. Saturated hydraulic conductivity is moderately high or high in the mineral solum and low through moderately high in the substratum.

USE AND VEGETATION: Many areas are cleared and used for cultivated crops, hay, or pasture. Scattered areas are used for community development. Some areas are wooded. Common trees are red, white, and black oak, hickory, sugar maple, red maple, gray and black birch, eastern white pine, and eastern hemlock.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, eastern New York, Rhode Island, and Vermont. MLRAs 144A and 145. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Worcester County, Massachusetts, 1922.

REMARKS: Paxton is the state soil of Massachusetts.

This revision reflects changes to the range in characteristics as well as general updating to metric units. Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils. Paxton soils were previously classified as Typic Dystrochrepts, and before that as Typic Fragiochrepts.

The Paxton series was previously used in some surveys in Maine. Maine has determined from soil temperature studies that the mesic soil temperature regime will no longer be used.

Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 through 8 inches (0 to 20 centimeters) (Ap horizon).
2. Cambic horizon - the zone from 8 through 26 inches (20 to 66 centimeters) (Bw horizons).
3. Dense till material - the zone from 26 through 65 inches (66 to 165 centimeters) (Cd horizon).
4. Oxyaquic subgroup - based on saturation in one or more layers within 100 cm of the mineral surface, for one month or more per year, in 6 out of 10 years.
5) Particle-size control section - the zone from 20 to 66 centimeters (Bw horizons).

ADDITIONAL DATA: Full characterization data for sample no.57MA023003, 55MA027001, 55MA027002, 58MA015001, 58MA015002, 55NH017001, 73MA005006, 77MA005006, 75CT013001, and 81VT021005. Pedons analyzed by the NSSL, Lincoln, NE.

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