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Surficial Geologic Map of the Pocasset-Provincetown-Cuttyhunk-Nantucket 24-Quadrangle Area of Cape Cod and Islands, Southeast Massachusetts

Compiled by Byron D. Stone and Mary L. DiGiacomo-Cohen

Open-File Report 2006-1260-E

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Cover figure. Photograph of eroding cliffs at Gay Head on Martha's Vineyard (source: Wikimedia Commons).

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

Surficial Geologic Map of the Pocasset-Provincetown-Cuttyhunk-Nantucket 24-Quadrangle Area of Cape Cod and Islands, Southeast Massachusetts

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Introduction

The surficial geologic map layer shows the distribution of nonlithified earth materials at land surface in an area of 24 7.5-minute quadrangles (555 mi^2 total) in southeast Massachusetts (fig. 1). Across Massachusetts, these materials range from a few feet to more than 500 ft in thickness. They overlie bedrock, which crops out in upland hills and as resistant ledges in valley areas. On Cape Cod and adjacent islands, these materials completely cover the bedrock surface. The geologic map differentiates surficial materials of Quaternary age on the basis of their lithologic characteristics (such as grain size and sedimentary structures), constructional geomorphic features, stratigraphic relations, and age. Surficial materials also are known in engineering classifications as unconsolidated soils, which include coarse-grained soils, fine-grained soils, and organic fine-grained soils. Surficial materials underlie and are the parent materials of modern pedogenic soils, which have developed in them at the land surface. Surficial earth materials significantly affect human use of the land, and an accurate description of their distribution is particularly important for assessing water resources, construction aggregate resources, and earth-surface hazards, and for making land-use decisions.

The mapped distribution of surficial materials that lie between the land surface and the bedrock surface is based on detailed geologic mapping of 7.5-minute topographic quadrangles, produced as part of an earlier (1938–1982) cooperative statewide mapping program between the U.S. Geological Survey and the Massachusetts Department of Public Works (now Massachusetts Highway Department) (Page, 1967; Stone, 1982). Each published geologic map presents a detailed description of local geologic map units, the genesis of the deposits, and age correlations among units. Previously unpublished field compilation maps exist on paper or mylar sheets and these have been rendered digitally for the present map compilation. Regional summaries based on the Massachusetts surficial geologic mapping studies discuss the ages of multiple glaciations, the nature of glaciofluvial, glaciolacustrine, and glaciomarine deposits, and the processes of ice advance and retreat across Massachusetts (Koteff and Pessl, 1981; papers in Larson and Stone, 1982; Stone and Borns, 1986; Warren and Stone, 1986).

This compilation of surficial geologic materials is an interim map product that defines the boundaries between glacial till, glacial moraine deposits, glacial stratified deposits, and overlying postglacial deposits. This area of 24 quadrangles differs from the rest of Massachusetts in that surficial moraine and stratified materials entirely cover the basal till and bedrock surfaces (Oldale

and Barlow, 1986; Masterson and others, 1997), which are shown on the basal layers of this map database. In addition, moraine deposits are more extensive and complex than elsewhere in Massachusetts. This work is part of a comprehensive study to produce a statewide digital map of the surficial geology at a 1:24,000-scale level of accuracy. This surficial geologic map layer covering 24 quadrangles revises previous digital surficial geologic maps (Stone and others, 1993; MassGIS, 1999) that were compiled on base maps at regional scales of 1:125,000 and 1:250,000. The purpose of this study is to provide fundamental geologic data for the evaluation of natural resources, hazards, and land information within the Commonwealth of Massachusetts.

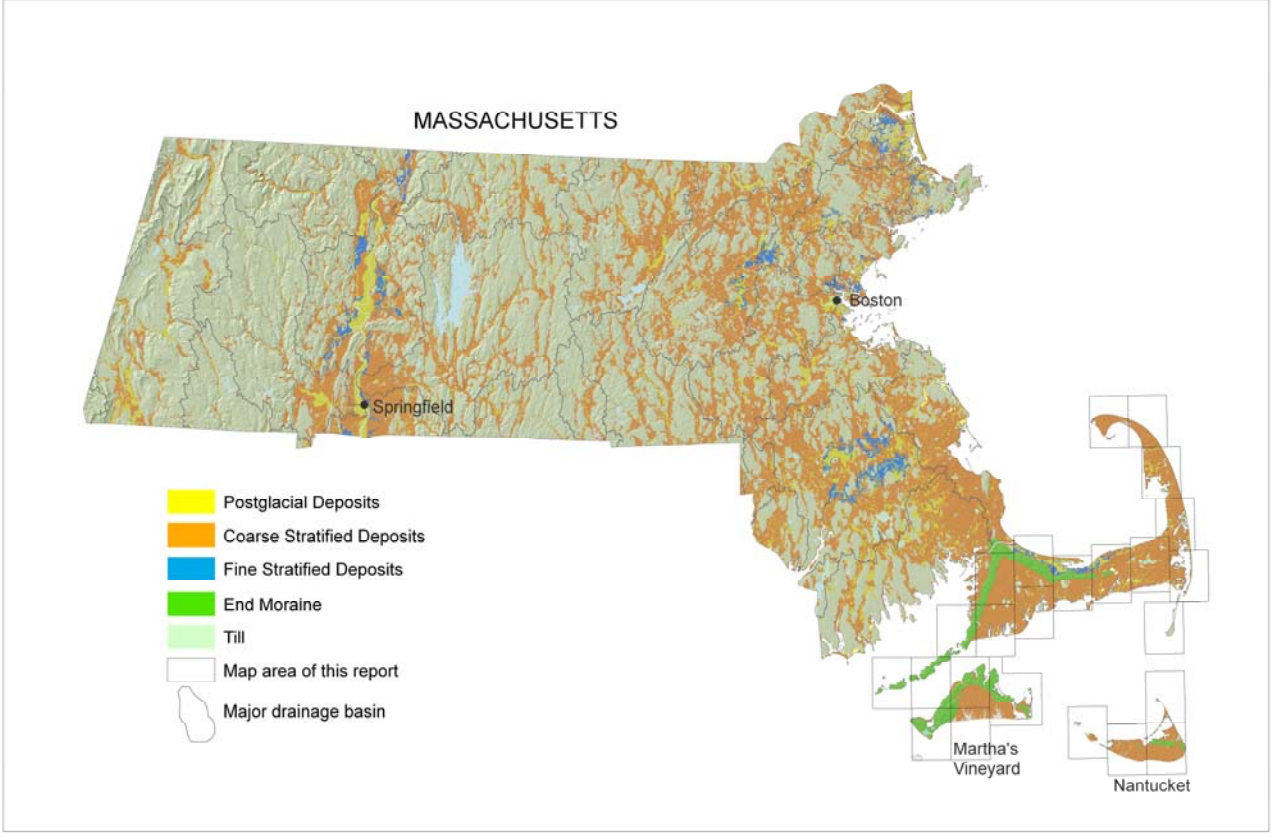


Figure 1. General distribution of glacial and postglacial deposits in Massachusetts (Stone and others, 1993; MassGIS, 1999) and 1:24,000-scale quadrangles covered by this report.

Surficial Materials in Massachusetts

Most of the surficial materials in Massachusetts are deposits of the last two continental ice sheets that covered all of New England in the latter part of the Pleistocene ice age (Schafer and Hartshorn, 1965; Oldale and others, 1982; Stone and Borns, 1986). In the Cape Cod and islands region, the glacial deposits are divided into three broad categories, ***glacial till, glacial moraine deposits,*** and ***glacial stratified deposits***. Glacial till, the most widespread glacial deposit in the subsurface, was laid down directly on bedrock by glacier ice. Glacial moraine deposits accumulated in ice-walled lakes and streams and on stagnant, buried ice in front of the receding edge of the ice

sheet. Glacial stratified deposits in the Cape Cod region were laid down by glacial meltwater in streams and lakes adjacent to large moraines in front of the retreating ice margin during the last deglaciation. Elsewhere in Massachusetts, stratified deposits are concentrated in valleys, lowland areas, and in marine embayments. Postglacial sediments, primarily swamp and marsh deposits, and valley-floor fluvial deposits, make up a lesser proportion of the unconsolidated materials.

Glacial till deposits consist of nonsorted, generally nonstratified mixtures of mineral and rock particles ranging in grain size from clay to large boulders. The matrix of most tills is composed dominantly of fine sand and silt. Boulders, within and on the surface of tills, range from sparse to abundant. Some tills contain lenses of sorted sand and gravel, and less commonly, masses of laminated fine-grained sediments. The color and lithologic characteristics of till deposits vary across Massachusetts but generally reflect the composition of the local underlying and northerly adjacent bedrock, from which the till was derived. Till blankets the bedrock surface in variable thickness, ranging from a few inches to more than 200 ft, and commonly underlies stratified meltwater deposits. Tills deposited during the last two glaciations occur in superposition within Massachusetts (Koteff, 1966; Newton, 1978; Weddle and others, 1989). The upper till was deposited during the last (late Wisconsinan) glaciation; it is the most extensive till and commonly is observed in surface exposures, especially in areas where till thickness is less than 15 ft (thin till unit on the map). The lower till ("old" till) was deposited during an earlier glaciation (probably Illinoian). The lower till has a more limited distribution; it is principally a subsurface deposit that constitutes the bulk of material in drumlins and other hills, where till thickness is greater than 15 ft. On eastern Nantucket Island, sandy and bouldery upper till at the surface overlies glacial stratified deposits and marine beds of Sangamon age that overlie till of probable Illinoian age (Oldale and others, 1982), which is correlated with the lower till on the mainland. Thin till deposits of late Wisconsinan age are shown on the basal, subsurface layer of this map where drill-hole data indicate the distribution of compact, sandy till that lies on bedrock or older coastal plain or early Pleistocene deposits.

Glacial moraine deposits are composed of a surface layer, 6 to 30 ft thick, of sandy and bouldery ablation till, local compact sandy till, or a layered, sandy and bouldery sediment of probable debris-flow origin. Two types of moraine deposits are shown on the map. In western Cape Cod, northern Martha's Vineyard, and the Elizabeth Islands, moraine deposits include thick subsurface deposits, composed of sorted and layered meltwater sediments, chiefly sand and fine gravel and minor silt and clay, as reported in drill hole descriptions. In northwestern Cape Cod, western Martha's Vineyard, and Nantucket, thrust-moraine deposits overlie glacially deformed older meltwater and marine deposits, chiefly sand and gravel. Sedimentary units in all of the moraines have limited lateral extent and irregular thickness; stratification is deformed by collapse structures around kettle depressions and by glaciotectonic folds and thrust faults in some deposits. These deposits were laid down along active ice margins during retreat of the last (late Wisconsinan) ice sheet. Extensive end moraines on Nantucket and Martha's Vineyard (fig. 1) are related to the terminal position of the late Wisconsinan ice sheet; the end moraines on Cape Cod are associated with recessional positions of the last ice sheet. Less extensive end moraines are present locally elsewhere in southeastern Massachusetts, in the Boston area, and in the Gloucester-Rockport area of northeastern Massachusetts. End-moraine deposits on western Martha's Vineyard contain a surface sandy till and are characterized by ice-thrusted beds of Tertiary fossiliferous sand, gravel, and silty clay deposits, and Pleistocene sand and silty clay beds (Shaler, 1898; Woodworth and Wigglesworth, 1934; Kaye, 1964).

Glacial stratified deposits consist of layers of well-sorted to poorly sorted gravel, sand, silt, and clay laid down by flowing meltwater in glacial streams, lakes, and marine embayments that occupied the valleys and lowlands of Massachusetts during retreat of the last ice sheet. Textural variations within the meltwater deposits occur both aerially and vertically because meltwater-flow regimes were different in glaciofluvial (stream), glaciodeltaic (where a stream entered a lake or the sea), glaciolacustrine (lake bottom), and glaciomarine (marine bottom) depositional environments. Grain-size variations also resulted from meltwater deposition in positions either proximal to, or distal from, the retreating glacier margin, which was the principal sediment source. A common depositional setting contained a proximal, ice-marginal meltwater stream in which horizontally bedded glaciofluvial gravel and (or) sand and gravel were laid down; farther down valley, the stream entered a glacial lake where glaciodeltaic sediments were deposited, consisting of horizontally layered sand and gravel delta-topset beds overlying inclined layers of sand in delta-foreset beds. Farther out in the glacial lake, very fine sand, silt, and clay settled out on the lake bottom in flat-lying, thinly bedded glaciolacustrine layers. Thick sequences having these textural variations commonly are present in the vertical section of meltwater deposits across the State and region (Stone and others, 1992). Detailed geologic maps typically show meltwater sedimentary units within each glacial lake or valley outwash system (Jahns, 1953; Koteff, 1966). These units, known as *morphosequences* (Koteff, 1974; Koteff and Pessl, 1981), are the smallest mappable stratigraphic units depictable on detailed geologic maps. Morphosequences are bodies of stratified meltwater sediments that are contained in a continuum of landforms, grading from ice-contact forms (eskers, kames) to non-ice-contact forms (flat valley terraces, delta plains) that were deposited simultaneously at and beyond the margin of the ice sheet, and are graded to a specific base level. Each morphosequence consists of a proximal part (head) deposited within or near the ice margin and a distal part deposited farther away from the ice margin. Both grain size and ice-melt collapse deformation of beds decrease from the proximal to the distal part of each morphosequence. The head of each morphosequence is either ice marginal (ice contact) or near ice marginal. The surface altitude of fluvial sediments in each morphosequence was controlled by a specific base level, either a glacial-lake or marine water plane or a valley knickpoint. Few morphosequences extend distally more than 6 miles; the most extensive morphosequences in Massachusetts are the glaciodeltaic outwash plains of Cape Cod and the islands of Nantucket and Martha's Vineyard. In any one basin, individual morphosequences were deposited sequentially as the ice margin retreated systematically northward. Consequently, in many places the distal, finer-grained facies of a younger morphosequence stratigraphically overlies the proximal, coarse-grained facies of a preceding morphosequence. Figure 2 shows the variability of sediment types in the subsurface of glacial stratified deposits. The figure schematically shows the relation between coarse-grained deltaic deposits (gravel and sand) and extensive fine-grained lake deposits (fine sand, silt, and clay) in the subsurface. Such coarse- and fine-grained units are common in most of the valleys and lowlands of Massachusetts and the region (Langer, 1979; Stone and others, 1979; Oldale and Barlow, 1986; Stone and others, 1992; Stone and others, 2005). On these interim maps, coarse-grained and fine-grained textural variations within glacial stratified deposits are shown only where they occur at land surface. Subsurface textural variations are not shown.

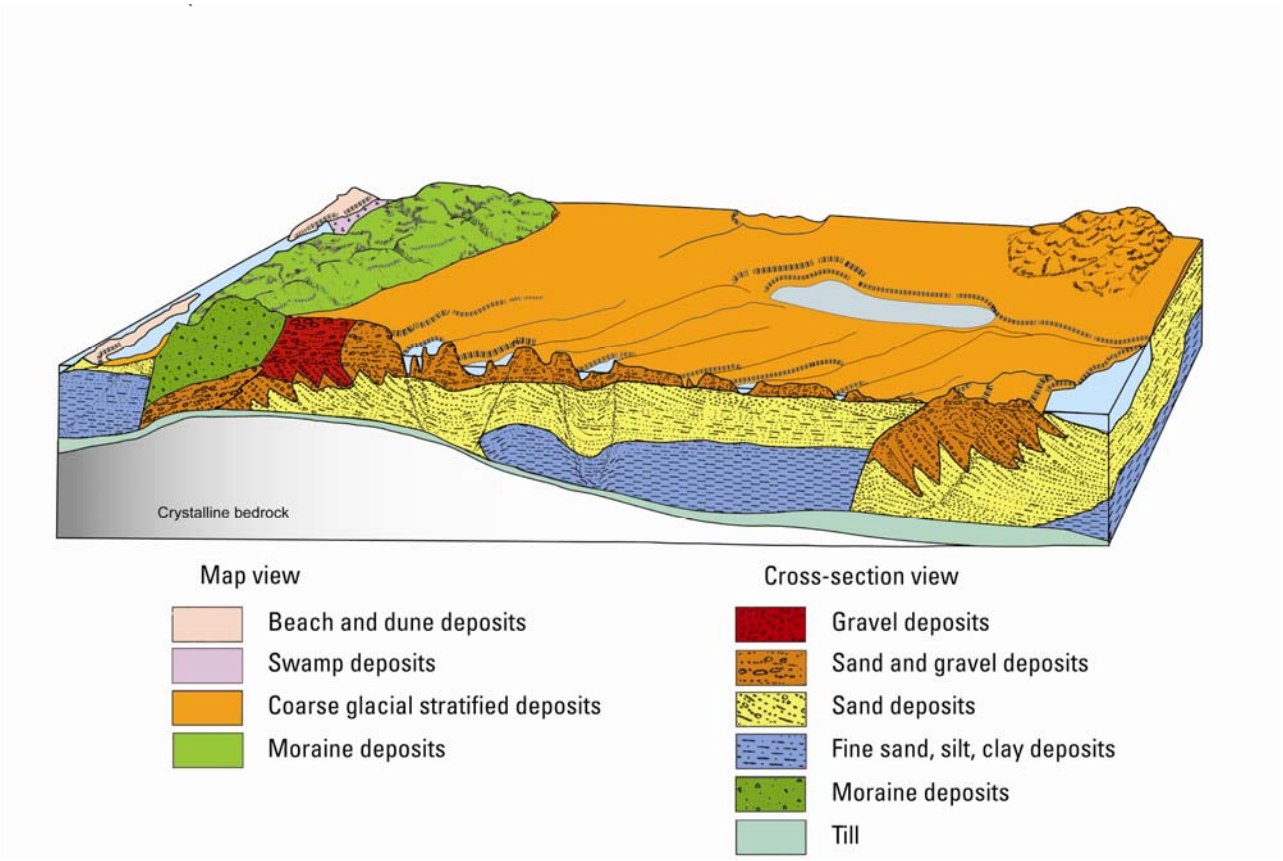


Figure 2. Block diagram illustrating the typical areal and vertical distribution of glacial and postglacial deposits overlying bedrock in the Cape Cod and islands region (modified from Strahler, 1966; Oldale, 1975a; and Masterson and others, 1997).

The aerial distribution of till and stratified deposits is related to the physiography of the State (fig. 1). The thickness of these materials varies considerably within these regions because of such factors as the high relief of the bedrock surface, changing environments of deposition during deglaciation, and various effects of postglacial erosion and removal of glacial sediments. In highland areas, notably in the western and central regions, till is the major surficial material, and is present as a discontinuous mantle of variable thickness over the bedrock surface. Till is thickest in drumlins (reportedly as much as 230 ft thick) and on the northwest slopes of most bedrock hills. Glacial meltwater deposits that average 50 ft in thickness (Stone and others, 1993) overlie the till in small upland valleys and north-sloping basins between bedrock hills. Glacial stratified deposits are the predominant surficial materials in the Connecticut River valley, the northeastern and southeastern lowlands, and on Cape Cod and the islands. These deposits generally overlie till; however, well logs indicate that in some places till is not present and the stratified deposits lie directly on bedrock. On Cape Cod and the islands, glacial stratified deposits are 100 to >500 ft thick, and, combined with moraine deposits, completely cover the subsurface till, coastal plain deposits, and bedrock. In the adjacent southeastern lowland, and in parts of the Connecticut River valley, extensive stratified deposits also cover the bedrock surface.

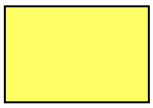
Postglacial deposits locally overlie the glacial deposits throughout the State. Swamp and marsh deposits occur in low-lying, poorly drained areas in upland and lowland settings, but these deposits are shown only where they are estimated to be at least 3 ft thick. Salt-marsh and estuarine deposits are present mainly along the tidal portions of streams and rivers entering the offshore areas. Valley-floor fluvial deposits, unique to the furrow valleys of this map area, underlie the floors of dry valley reaches. Small alluvial deposits are mappable only in areas of moraine deposits on Martha's Vineyard and near Cataumet, Cape Cod. Beach and dune deposits occur along the shoreline.

Description of Map Units

Postglacial Deposits

Artificial fill—Earth materials and manmade materials that have been artificially emplaced, primarily in highway and railroad embankments, and in dams; may also include landfills, urban development areas, and filled coastal wetlands

Cranberry bog—Mostly freshwater swamps or peat bogs overlain locally by artificially emplaced sand or other fill



Alluvium—Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, in narrow valleys of small modern streams. Most alluvial deposits in the Cape Cod region are not extensive enough to be shown on the map. The only mapped surface alluvial deposits are discontinuous deposits along Black, Paint Mill, Mill, and Roaring Brooks and the Tiasquam River, all on Martha's Vineyard, and near Cataumet, in the Pocasset quadrangle. Alluvium overlies thicker glacial moraine and stratified deposits, and thin alluvial deposits probably lie beneath salt-marsh deposits in coastal valley reaches that were flooded during the postglacial rise of sea level

Swamp and marsh deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, stratified and poorly sorted, in freshwater swamps and marshes, kettle depressions, or poorly drained areas. Swamp and marsh deposits are shown only where they are estimated to be at least 3 ft thick. Most swamp and marsh deposits are less than 10 ft thick. Swamp deposits overlie glacial meltwater deposits and postglacial pond deposits in kettle depressions. Unit includes salt-marsh deposits not differentiated on previously published quadrangle maps

Salt-marsh deposits—Peat and organic muck interbedded with sand and silt, deposited in saltwater or brackish-water environments of low wave energy along the coast and in river estuaries. Salt-marsh deposits are generally a few feet to 25 ft thick. In the major estuaries, these deposits locally overlie estuarine deposits (not mapped), which are sand and silt with minor organic material as much as 30 to 80 ft thick. The

salt-marsh and estuarine deposits generally are underlain by adjacent glacial stratified deposits

Beach and dune deposits—Sand and fine gravel deposited along the shoreline by waves and currents, and by wind action. The texture of beach deposits varies over short distances and is generally controlled by the texture of nearby glacial materials exposed to wave action. Sand beach deposits are composed of moderately sorted, very coarse to fine sand, commonly laminated. Coarser layers locally contain some fine gravel particles; finer layers contain some very fine sand and silt. Gravel beach deposits are composed of granule- to cobble-size clasts in moderately sorted thin beds; deposits contain minor amounts of sand within gravel beds, and thin beds of sand as alternating layers. Beach deposits are rarely more than a few feet thick. Dune deposits are composed of moderately to well sorted, fine to medium sand, variably massive, laminated, and crossbedded. Dune deposits are as much as 100 ft thick. Unit includes artificial sand deposits in locally replenished beaches

Valley-floor fluvial deposits—Sand, gravel, and minor silt, stratified and moderately to poorly sorted, beneath flat floors of valleys, called furrows (Mather and others, 1942) that are eroded into glacial outwash plains. The texture of the fluvial deposits commonly varies over short distances both laterally and vertically and generally is similar to the texture of adjacent glacial deposits. The fluvial deposits overlie thick glacial stratified deposits in the upper, dry reaches of the furrow valleys and probably are less than 20 ft thick. Swamp deposits and deformation of bedding related to melting of buried ice in kettles interrupt the fluvial deposits. The deposits probably extend beneath salt-marsh deposits in coastal valley reaches. The most extensive valley fluvial deposits are along Quaker Run and Coonamessett, Childs, and Quashnet Rivers on upper Cape Cod, and Quampachje Bottom on Martha's Vineyard

Glacial Stratified Deposits

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in particle-size diagram, fig. 3) deposited in layers by glacial meltwater. These sediments occur as four basic textural units—gravel deposits, sand and gravel deposits, sand deposits, and fine deposits. On this interim surficial geologic map layer, gravel, sand and gravel, and sand deposits are not differentiated and are shown as *Coarse Deposits* where they occur at land surface. *Glaciolacustrine Fine Deposits* also are shown where they occur at land surface. Textural changes occur both aerially and vertically (fig. 2), however subsurface textural variations are not shown on this interim map.

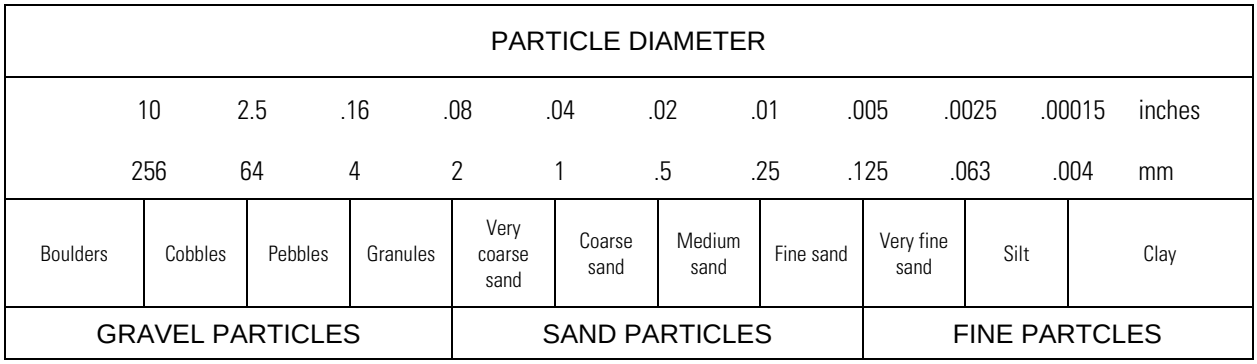


Figure 3. Grain-size classification used in this report, modified from Wentworth (1922).

Coarse deposits include *Gravel deposits* composed of at least 50 percent gravel-size clasts; cobbles and boulders predominate; minor amounts of sand occur within gravel beds, and sand composes few separate layers. Gravel layers generally are poorly sorted and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* are composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* are composed mainly of very coarse to fine sand, commonly in moderately sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay

Glaciolacustrine fine deposits include very fine sand, silt, and clay that occur as well-sorted, thin layers of alternating silt and clay, or thicker layers of very fine sand and silt. Very fine sand commonly occurs at the surface and grades downward into rhythmically bedded silt and clay varves. Locally, this map unit may include areas underlain by fine sand

Glacial Till and Moraine Deposits

Moraine deposits—Surface deposits of nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; predominantly till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies of till are present in some places: a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer-grained lodgement facies deposited subglacially. Both ablation and lodgement facies of till are stony, containing boulders, and are derived from coarse-grained crystalline rocks. The surface nonsorted deposits, 6 to 30 ft thick, overlie

sand, gravel, and silty sand meltwater deposits that extend downward to basal till and bedrock. Surface deposits and stratification in underlying sediments commonly are distorted and faulted due to postdepositional collapse related to melting of buried ice

Thrust-moraine deposits—Surface deposits of nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and large boulders; predominantly till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies of till are present in some places: a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer-grained lodgement facies deposited subglacially. Both ablation and lodgement facies of till are stony, containing boulders, and are derived from coarse-grained crystalline rocks. In western Martha's Vineyard, thrust-moraine deposits include thin surface till and subsurface ice-thrusted beds of Tertiary fossiliferous sand, gravel, and silty clay deposits, and Pleistocene sand and silty clay beds. In eastern Nantucket, moraine deposits include thin surface till and ice-thrusted beds of sandy glacial meltwater deposits, interglacial marine sand, and older till at the base

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; predominantly upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places: a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer-grained lodgement facies deposited subglacially. Both ablation and lodgement facies of upper till are sandy and stony, and derived from coarse-grained crystalline rocks. Unit includes till of probable Illinoian age beneath eastern Nantucket (Oldale and others, 1982). Beneath Cape Cod, subsurface till overlies fresh, nonweathered bedrock; this basal till varies in known thickness from <5 to >50 ft (Cotton and Koteff, 1962; Masterson and others, 1997; Folger and others, 1978; Hall and others, 1980). Till may overlie Cretaceous, Tertiary, or older Pleistocene deposits beneath the adjacent islands

Map Compilation

This compilation is the fifth in a series of interim products and shows surficial geology in an area of 24 7.5-minute quadrangles in Cape Cod and adjacent islands, southeast Massachusetts. The quadrangles are Provincetown, North Truro, Wellfleet, Orleans, Sandwich, Chatham, Harwich, Dennis, Hyannis, Pocasset, Cotuit, Monomoy Point, Falmouth, Woods Hole, Edgartown, Vineyard Haven, Naushon Island, Cuttyhunk, Great Point, Tuckernuck Island, Tisbury Great Pond, Squibnocket, Siasconset, and Nantucket (fig. 4; fig. 5, area E). Small portions of the Onset and Sagamore quadrangles have also been included in this compilation area. Figure 5 shows all of the compilation areas for surficial geology in Massachusetts. These surficial geologic map layers will be produced sequentially by letter designation.

The surficial geologic map layer was compiled in several steps:

1) Paper copies of the published surficial geologic maps for 14 quadrangles were scanned and georeferenced by MassGIS.

2) The Office of the Massachusetts State Geologist vectorized the georeferenced images in order to digitally retain the original linework of the published maps (Mabee and others, 2004).
3) Digital geologic map units were compiled and grouped into basic units in three broader categories: *Postglacial deposits* including artificial fill, swamp deposits, beach and dune deposits, and alluvium; *glacial stratified deposits* including coarse-grained and glaciolacustrine fine-grained deposits; and *glacial till and moraine deposits.* The distribution of glacial stratified deposits beneath postglacial deposits and water bodies was inferred by the compilers. The distribution of thin till was inferred by the compilers from drill-hole data.
4) The same basic units for ten unpublished quadrangles were compiled and digitized from scanned field compilation maps by U.S. Geological Survey personnel.
5) The 24 individual quadrangle maps were joined and edge-matched in order to form a seamless digital geologic map layer. Discrepancies along quadrangle boundaries were resolved, and thin till was added as the basal layer by the compilers on the basis of limited subsurface data.

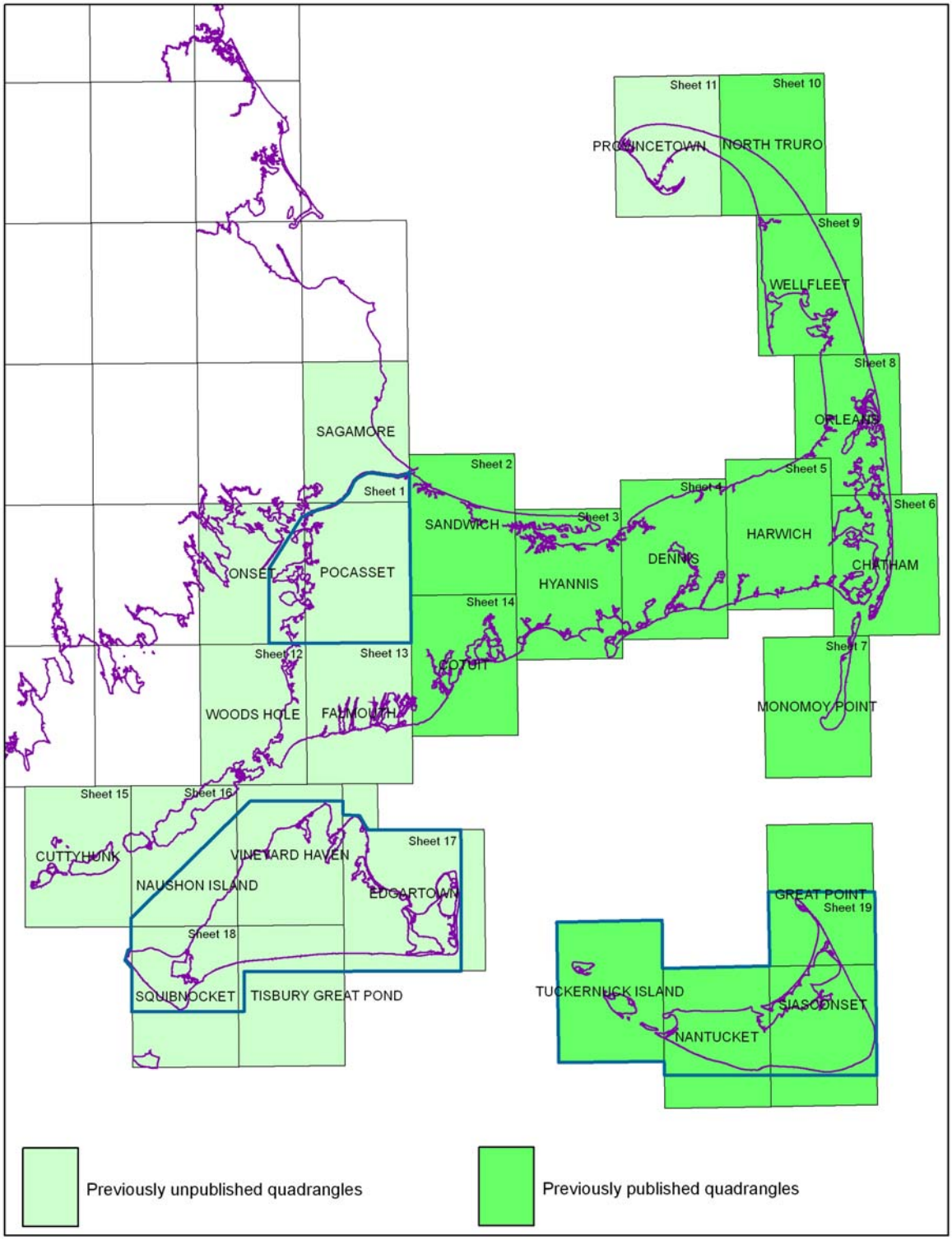


Figure 4. USGS 7.5-minute, 1:24,000-scale quadrangles in this compilation. Sheet numbers refer to Adobe PDF map files of individual quadrangles or groups of quadrangles in area maps (blue outlines).

All geologic mapping was completed at 1:24,000 scale. The 1:24,000-scale, 10-ft-contour-interval topographic base maps (1951–1974 editions) used for this geologic map are included as part of the digital data package in the *24k_basemaps* folder. The GIS folder included with this report contains three ArcGIS shapefiles, which show the distribution of geologic units that cover the entire map area, and are intended for use at quadrangle scale. The shapefiles can be clipped by quadrangle or town boundaries. Unlike conventional geologic maps, the digitally defined map units are arranged in layers according to superposition. The shapefile for thin till and moraine deposits is the bottom layer, which is overlain by the succeeding stratified deposits shapefile layer; these materials are shown everywhere that they occur, including beneath postglacial deposits such as swamp deposits, and alluvium, and water bodies. The shapefile for postglacial deposits is the top layer because these materials overlie the older materials in the other two layers. Instructions for using the digital files are included in the README file and metadata.

In addition to the seamless digital layers that cover the entire compilation area, Adobe PDF map files of the surficial geology layers shown with 1:24,000-scale topographic base-map images have been generated for most quadrangles (see Sheets 1–19, fig 4.). For convenience and continuity, the 1:24,000-scale PDF maps of Martha's Vineyard, Nantucket, and the Cape Cod Canal area have been created as larger sheets instead of individual quadrangles.

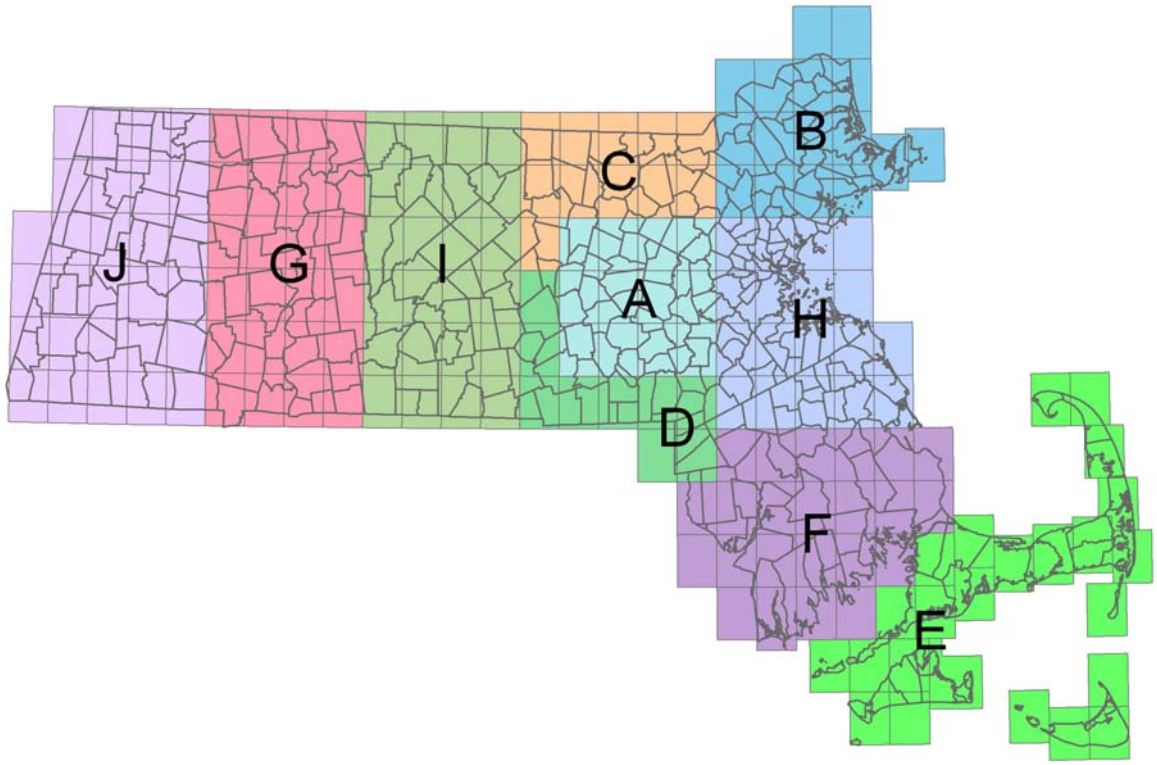


Figure 5. Compilation areas in Massachusetts. Letters represent sections in Open-File Report 2006-1260. Published sections are available online at *http://pubs.usgs.gov/of/2006/1260/.*

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Appendix

Sources of Data by 7.5-Minute Quadrangle

Provincetown Quadrangle

Hartshorn, J.H., 1967, unpublished field compilation map. Some postglacial units mapped using 2005 orthophoto images.

North Truro Quadrangle

Map units were reproduced from Koteff and others (1967). Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic deposits.

Wellfleet Quadrangle

Map units were reproduced from Oldale (1968). Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay.

Orleans Quadrangle

Map units were reproduced from Oldale and others (1971). Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic deposits. Glaciolacustrine fine deposits at land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale and others, 1971).

Sandwich Quadrangle

Map units were reproduced from Oldale (1975b). Moraine deposits in this quadrangle are deposits of the Sandwich moraine. Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic deposits. Glaciolacustrine fine deposits at land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1975b).

Chatham Quadrangle

Map units were reproduced from Oldale and Koteff (1970). Glacial Stratified Deposits in this quadrangle include glaciofluvial, glaciodeltaic, and kame deposits.

Harwich Quadrangle

Map units were reproduced from Oldale (1969). Moraine deposits in this quadrangle are deposits of the Sandwich moraine. Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic deposits. Glaciolacustrine fine deposits at land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale, 1969).

Dennis Quadrangle

Map units were reproduced from Oldale (1974a). Moraine deposits in this quadrangle are deposits of the Sandwich moraine. Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial, glaciolacustrine, and kame deposits. Glaciolacustrine

fine deposits at land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb2 of Oldale, 1974a).

Hyannis Quadrangle

Map units were reproduced from Oldale (1974b). Moraine deposits in this quadrangle are deposits of the Sandwich moraine. Glacial Stratified Deposits include glaciofluvial, glaciodeltaic, and kame deposits. Glaciolacustrine fine deposits at land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1974b).

Pocasset Quadrangle

Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps; Masterson and others (1997). Moraine deposits in this quadrangle are deposits of the Sandwich and Buzzards Bay moraines. Glacial Stratified Deposits include glaciofluvial and glaciodeltaic deposits. Some postglacial units mapped using 2005 orthophoto images.

Sagamore Quadrangle

Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps; Masterson and others (1997). Moraine deposits in this quadrangle are deposits of the Sandwich moraine. Glacial Stratified Deposits include glaciofluvial and glaciodeltaic deposits. Some postglacial units mapped using 2005 orthophoto images.

Onset Quadrangle

Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps; Masterson and others (1997). Glacial Stratified Deposits include glaciofluvial and glaciodeltaic deposits. Some postglacial units mapped using 2005 orthophoto images.

Cotuit Quadrangle

Map units were reproduced from Oldale (1975a). Glacial Stratified Deposits in this quadrangle include glaciofluvial, glaciodeltaic, and kame deposits. Some postglacial units mapped using 2005 orthophoto images.

Monomoy Point Quadrangle

Map units were reproduced from Koteff and others (1968).

Falmouth Quadrangle

Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps; Masterson and others (1997). Moraine deposits in this quadrangle are deposits of the Buzzards Bay moraine. Glacial Stratified Deposits include glaciofluvial and glaciodeltaic deposits. Some postglacial units mapped using 2005 orthophoto images.

Woods Hole Quadrangle

Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps; Masterson and others, 1997. Moraine deposits in this quadrangle are deposits of the Buzzards Bay moraine. Some postglacial units mapped using 2005 orthophoto images.

Edgartown Quadrangle
Map units were modified from Kaye (1972); Stone, B.D., 1982, unpublished field maps. Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.

Vineyard Haven Quadrangle
Map units were modified from Kaye (1972); Stone, B.D., 1982, unpublished field maps. Moraine deposits in this quadrangle are deposits of the Martha's Vineyard moraine. Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.

Naushon Island Quadrangle
Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps. Moraine Deposits in this quadrangle are deposits of the Buzzards Bay moraine. Some postglacial units mapped using 2005 orthophoto images.

Cuttyhunk Quadrangle
Mather, Goldthwait, and Thiesmeyer, 1942, unpublished field maps; Stone, B.D., 1982, unpublished field maps. Moraine Deposits in this quadrangle are deposits of the Buzzards Bay moraine. Some postglacial units mapped using 2005 orthophoto images.

Great Point Quadrangle
Map units were reproduced from Oldale (1985). Some postglacial units mapped using 2005 orthophoto images.

Tuckernuck Island Quadrangle
Map units were reproduced from Oldale (1985). Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.

Tisbury Great Pond Quadrangle
Map units were modified from Kaye (1972); Stone, B.D., 1982, unpublished field maps. Moraine deposits in this quadrangle are deposits of the Martha's Vineyard moraine. Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.

Squibnocket Quadrangle
Map units were modified from Kaye (1972); Stone, B.D., 1982, unpublished field maps. Moraine deposits in this quadrangle are deposits of the Martha's Vineyard moraine. Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.

Siasconset Quadrangle
Map units were reproduced from Oldale (1985). Moraine deposits in this quadrangle are deposits of the Nantucket moraine. Glacial Stratified Deposits in this quadrangle include glaciofluvial and glaciodeltaic deposits. Some postglacial units mapped using 2005 orthophoto images.

Nantucket Quadrangle

Map units were reproduced from Oldale (1985). Moraine deposits in this quadrangle are deposits of the Nantucket moraine. Glacial Stratified Deposits in this quadrangle are glaciofluvial deposits. Some postglacial units mapped using 2005 orthophoto images.