National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Minute Man National Historical Park

Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory Digital Geologic Data for Minute Man National Historical Park

mima_geology.pdf

Version: 4/16/2020

Geologic Resources Inventory Map Document for Minute Man National Historical Park

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Geologic Resources Inventory Map Document

Minute Man National Historical Park, Massachusetts

Document to Accompany Digital Geologic-GIS Data

mima_geology.pdf

Version: 4/16/2020

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Minute Man National Historical Park, Massachusetts (MIMA).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1)**About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2)**GRI Digital Maps and Source Citations** – A listing of the GRI digital geologic-GIS maps produced for this project along with source maps used in their completion. In addition, a brief explanation of how each source map was used is provided. An index map showing Minute Man National Historical Park, and the GRI map extents is also provided. A brief discussion of the newer and older (legacy) GRI maps, and how these maps relate to the 2009 GRI report is also presented.

3)**Digital Bedrock Geologic-GIS Map of Minute Man National Historical Park**

a.) **Map Unit List** – A listing of all bedrock map units present on this map, generally listed from youngest to oldest.

b.) **Map Unit Descriptions** – Descriptions for all bedrock map units.

c.) **Ancillary Source Map Information** – Additional source map information present on the source map.

d.) **Previous GRI (Bedrock) Map Unit Listing** – A listing of bedrock units as they were initially listed in the earlier GRI version of this map, as well as in the GRI Report for Minute Man National Historical Park.

4)**Digital Surficial Geologic-GIS Map of Minute Man National Historical Park**

a.) **Map Unit List** – A listing of all surficial map units present on this map, listed from youngest to oldest.

b.) **Map Unit Descriptions** – Descriptions for all surficial map units.

c.) **Ancillary Source Map Information** – Additional source map information present on the source map.

5)**GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
Fort Collins, CO 80523
phone: (970) 491-6655
e-mail: stephanie_o'meara@partner.nps.gov

About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm.

Geologic Reports: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: https://go.nps.gov/gripubs. GRI digital geologic-GIS data is also available online at the NPS Data Store: https://irma.nps.gov/DataStore/Search/Quick. To find GRI data for a specific park or parks select the appropriate park(s), enter “GRI” as a Search Text term, and then select the Search button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://

www.nps.gov/subjects/geology/gri.htm. At the bottom of that webpage is a “Contact Us” link if you need additional information. You may also directly contact the program coordinator:

Jason Kenworthy
Inventory Report Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 987-6923
fax: (303) 987-6792
email: Jason_Kenworthy@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division. Learn more about I&M and the 12 baseline inventories at the I&M webpage: https://www.nps.gov/im/inventories.htm.

GRI Digital Maps and Source Map Citations

The GRI digital geologic maps for Minute Man National Historical Park, Massachusetts (MIMA) are listed below. The source maps used to produce each map are also listed.

Digital Bedrock Geologic-GIS Map of Minute Man National Historical Park and Vicinity, Massachusetts (*GRI MapCode MIMA*)

Langford, C.D., and Hepburn, C.J., 2007, Preliminary Bedrock Geologic Map of the Concord Quadrangle, Massachusetts: Boston College, Master's Thesis, scale 1:24,000 (*GRI Source Map ID 74982*).

The GRI used the full extent of the source map, and captured all geologic features within the map extent. In addition, source map elements (e.g., unit colors, unit descriptions, ancillary map graphics and text) were also incorporated into the GRI digital geologic-GIS dataset and product.

Hansen, W.R., 1956, Geology and Mineral Resources of the Hudson and Maynard Quadrangles, Massachusetts (plate 1: Map and Sections Showing Bedrock Geology): U.S. Geological Survey, Bulletin 1038, plate 1 of 3, scale 1:24,000 (*GRI Source Map ID 2772*).

The GRI used only a partial extent of the source map, however, all geologic features within the extent where captured. The extent of the source map used was that of the a 2.5' by 2.'5 area in the northeastern corner of the Maynard 7.5' quadrangle. Relevant source map elements (e.g., unit colors, unit descriptions, ancillary map graphics and text) were also incorporated into the GRI digital geologic-GIS dataset and product.

Digital Surficial Geologic-GIS Map of Minute Man National Historical Park and Vicinity, Massachusetts (*GRI MapCode MIMA_surficial*)

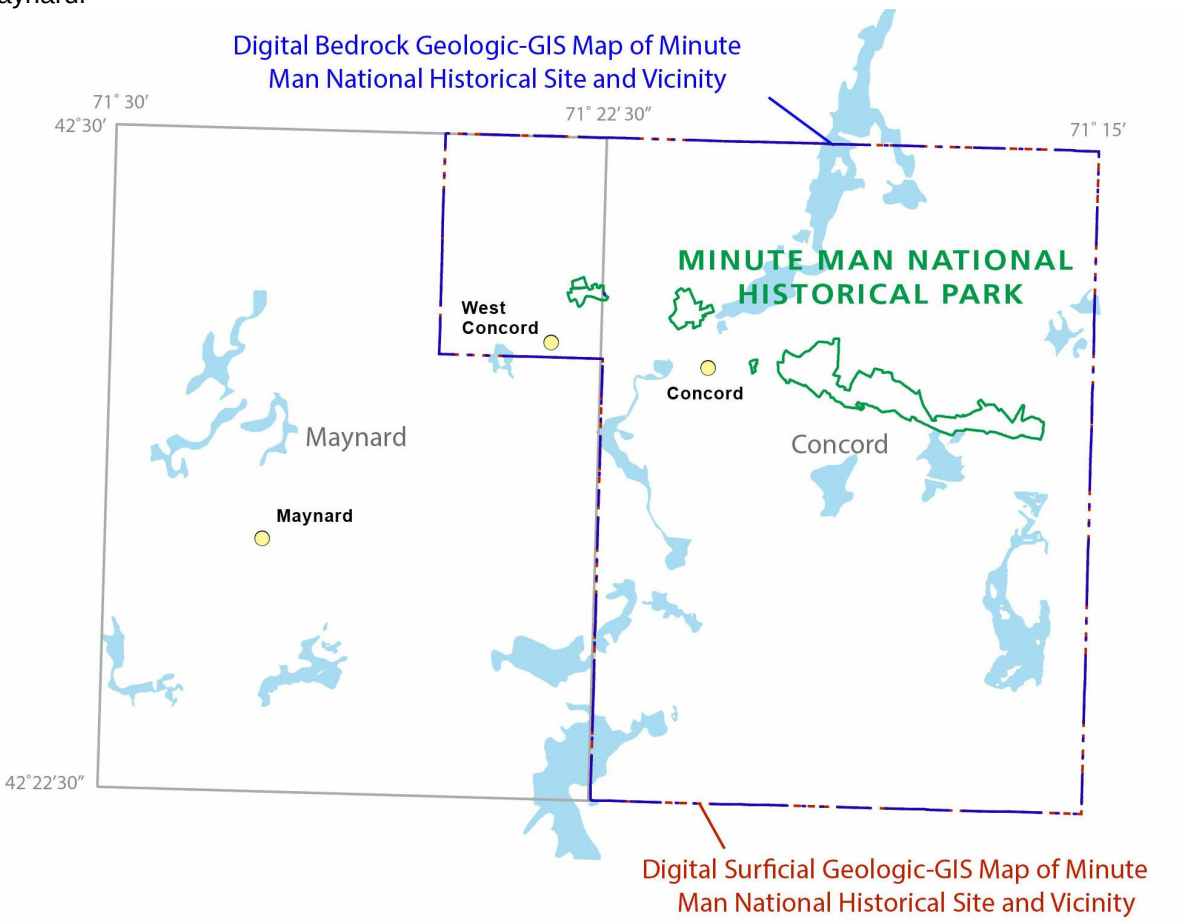
Stone, J.R., and Stone, B.D., 2006, Surficial Geologic Map of the Clinton-Concord-Grafton-Medfield 12 Quadrangle Area in East Central Massachusetts: U.S. Geological Survey, Open File Report OF-2006-1260A, scale 1:50,000. (*GRI Source Map ID 74750*).

The GRI used only a partial extent of the source map, however, all geologic features within the extent where captured. The extent of the source map used was that of the Concord 7.5' quadrangle, and a 2.5' by 2.'5 area in the northeastern corner of the Maynard 7.5' quadrangle. Relevant source map elements (e.g., unit colors, unit descriptions, ancillary map graphics and text) were also incorporated into the GRI digital geologic-GIS dataset and product.

Additional information pertaining to each source map is also presented in the GRI Source Map Information (MIMAMAP) table included with the GRI geologic-GIS data.

Index Map

The following index map displays the shared map extents (blue and red line) of the GRI Digital Bedrock Geologic-GIS Map of Minute Man National Historical Park and Vicinity (*GRI Map Code MIMA*) and the GRI Digital Surficial Geologic-GIS Map of Minute Man National Historical Park and Vicinity (*GRI Map Code MIMA_surficial*). The boundary for Minute Man National Historical Park (as of April, 2020) is outlined in green. The index map also displays the extents of the Concord and Maynard 7'5' quadrangles, as well as prominent towns and villages in the area: Concord, West Concord and Maynard.



Index map produced by Sarah Lowe and Stephanie O'Meara (Colorado State University).

Digital Bedrock Geologic-GIS Map of Minute Man National Historic Site

Map Unit List

The bedrock units present in the Digital Bedrock Geologic-GIS Map of Minute Man National Historic Site and Vicinity, Massachusetts (*GRI MapCode MIMA*) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Dihh - Indian Head Hill Igneous Complex). Units are listed in order of youngest to oldest, however, in some cases the unit age is not exactly known. In these cases the unit is either listed as per the source map unit listing order, or by noting the youngest unit the unit in question intrudes into if an intrusive rock. Information about each geologic unit is also presented in the Geologic Unit Information (MIMAUNIT) table included with the GRI digital geologic-GIS data.

Of note, several bedrock unit symbols have been changed from the previous version of this map. In addition, many of these changed unit symbols are referenced in the GRI Report for Minute Man National Historic Site (Thornberry-Ehrlich, 2017) with the older legacy unit symbol. The change of unit symbols was made in most cases so that these unit symbols now adhere to commonly accepted unit symbol standards. In many cases the unit symbol time designation (uppercase letters) was reversed so that the younger period of geologic time is listed first, as per commonly accepted standards. The source map, and the earlier version of this map, as well as the GRI report, didn't list unit time symbols in this order. As an example, unit SZfhg was previously assigned the unit symbol ZSfhg. Another change is for the unit time symbol of the Waltham Granite which was previously "MZ", however, to denote the unit as mid-Paleozoic the unit time symbol was changed to "PZ". Previous unit symbols are presented with each unit's description.

The order of bedrock units on the source map, based on the geologic terrane (Nashoba Terrane or Avalon Terrane) and rock type (igneous rocks, stratified rocks and tectonized-mylonitized rocks) is presented in the Previous GRI (Bedrock) Map Unit Listing section of this document.

Mesozoic Era
MZd – diabase

Paleozoic Era

Devonian Period
Dihh – Indian Head Hill Igneous Complex
UNKhhg – Hubbard Hill Gabbro
Dcrs – Cambridge Reservoir Suite

Devonian and Silurian Periods
DSphgd – Prospect Hill Gabbro-Diorite

mid-Paleozoic Era
PZwgr – Waltham Granite

Devonian and Silurian Periods
DSwd – White Pond Gabbro
DSag – Andover Granite
DSap – Pegmatite
DSaqd – Assabet Quartz Diorite

Ordovician to Devonian Periods
DOsic – Sudbury Valley Igneous Complex

Paleozoic Era and older

Devonian Period to Neoproterozoic Era
DZwgh – Weston Group, Hornblende Member
DZwghb – Weston Group, Hornblende-Biotite Member
DZwgp – Weston Group, Plagioclase-Hornblende-Biotite Member
DZwgm – Weston Group, Mylonitized Member

Paleozoic Era

Silurian Period
Sls – Lexington Suite
Sgr – Sudbury Granite
  Sgrd – Sudbury Granite, Dark Phase
  Sgrm – Sudbury Granite, Mixed Phase

Paleozoic Era and older

Silurian Period to Neoproterozoic Era
SZfhg – Fiske Hill Granite

Intrusive dikes of Unknown Age*
bd - Basic dike*

Paleozoic Era

Ordovician Period
Odgd – Draper Gabbro-Diorite

Ordovician and Cambrian Periods
OCnu – Nashoba Formation, undifferentiated
OCnbh – Nashoba Formation, Balls Hill Gneiss
OCna – Nashoba Formation, amphibolite
OCns – Nashoba Formation, schist
OCnp – Nashoba Formation, pegmatite
OCm – Marlboro Formation
OCmjs – Marlboro Formation, Jupiter Ridge Schist Member

Neoproterozoic Era

Zwm – Westboro Formation, Mylonite
UNKkgu – Kendall Green Ultramylonite
UNKchm – Cranberry Hill Mylonite
Zhm – Haywood Brook Mylonite
Zv – Mafic to Felsic Tectonite

* Basic dikes (unit bd) are represented in the GRI digital geologic-GIS data in the Point Geologic Units GIS data layer.

Bedrock Outcrops and Shallow Bedrock (areas) are present in the GRI digital geologic-GIS data in the Outcrops and Shallow Bedrock data layer. The map unit(s) of an outcrop or area of shallow bedrock area are not indicated in this GIS data layer.

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

MZd - Diabase (Mesozoic)

Small intrusions of very fine-grained, unaltered, massive diabase. Description from source map: Concord Quadrangle (Bedrock).

Dihh - Indian Head Hill Igneous Complex (Mississippian and Devonian)

A multi-phase suite of igneous rocks consisting of three principal lithologies intermixed at sub-mapping scale:

1.) Granodiorite: Light- to medium-gray, brownish-yellow to greenish-gray weathering, medium- to coarse-grained, massive to weakly foliated granodiorite to quartzmonzodiorite. Composed mainly of plagioclase, potassium feldspar, quartz, biotite, muscovite, epidote ±hornblende.
2.) Granite: Light-gray to pink on weathered surfaces, fine- to medium-grained, massive granite to granodiorite. Composed of potassium feldspar, plagioclase, quartz, muscovite, biotite, ±hornblende. Age: 349 ± 4 Ma (U-Pb/zircon, titanite; Hepburn et al., 1995).
3.) Diorite: Dark-greenish-gray, very fine-grained, nearly aphanitic, massive diorite. Hard and closely jointed. Composed of plagioclase and hornblende. Age: 402 ± 5 Ma (Rb-Sr/whole-rock; Hill et al., 1984).

Description from source map: Concord Quadrangle (Bedrock).

UNKhhg - Hubbard Hill Gabbro (age unknown)

Dark-gray to black, medium-grained, rusty weathering, gabbro. Intrudes the Nashoba Formation (OZn). Named for Hubbard Hill, Concord. Description from source map: Concord Quadrangle (Bedrock).

Age of unit is unknown.

Dcrs - Cambridge Reservoir Suite (Devonian)

Suite of rocks after Kohut (1999), mapped as Salem Gabbro-diorite by Emerson (1917) and Zdigb by Zen et al. (1983) including:

1.) Gabbro-diorite: Dark-blue-gray, medium- to coarse-grained, hornblende-bearing, gabbro-diorite. Thin veins of epidote common. Intruded by all other members of the suite.
2.) Gabbro-diorite: Dark-gray, fine- to very fine-grained, pyroxene- and hornblende-bearing gabbro-diorite. Intruded by white and tan granites. Intrudes coarse grained gabbro-diorite.
3.) Granite: White with a greenish tinge, medium- to coarse-grained, mafic poor granite-alaskite.

4.) Granite: Tan, fine-grained, biotite- and hornblende-bearing granite.

Description from source map: Concord Quadrangle (Bedrock).

DSphgd - Prospect Hill Gabbro-Diorite (Devonian to Silurian?)

Medium-gray, medium-grained, pyroxene-bearing gabbro-diorite with a diabasic texture. Laths of gray plagioclase with interstitial dark gray to black pyroxenes common. Composition more subalkaline than other mafic rocks locally in the Avalon Terrane (Kohut, 1999). Intrudes the Waltham Granite (PZwgr) and Lexington Suite (Sls). Description from source map: Concord Quadrangle (Bedrock).

PZwgr - Waltham Granite (Mid-Paleozoic?)

Creamy to orange-pink, fine- to medium-grained, mafic poor granite with a sugary texture. Greenish black specks of hornblende common. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as MZwgr.

DSwd - White Pond Gabbro (Devonian? to Silurian?)

Medium-gray to dark-greenish-gray, fine- to medium-grained, rusty weathering, generally massive, equigranular, biotite-hornblende tonalite to diorite. Intrudes the Andover Granite (DSag) and the Nashoba Formation (OCu). Possibly correlative with Sharpner's Pond Diorite. Named for White Pond, Concord. Description from source map: Concord Quadrangle (Bedrock).

DSag - Andover Granite (Devonian to Silurian?)

Light-gray to white to light-pink on fresh surfaces, weathers to light-dull-gray, medium- to coarse-grained, massive unfoliated to strongly foliated, granite to pegmatite. Composed chiefly of alkali feldspar, plagioclase, quartz, muscovite, ±biotite, and ±garnet. Intrudes the Marlboro (Com) and Nashoba Formations (OZn). Age of crystallization of massive granite: 412 ± 2 Ma (U-Pb/zircon; Hepburn et al.,1995); foliated granite: 446 ± 32 Ma (Rb-Sr/whole-rock; Zartman and Naylor, 1991). Description from source map: Concord Quadrangle (Bedrock).

DSap - Pegmatite (Devonian to Silurian?)

Small bodies of granite pegmatite occur in nearly every outcrop of the Nashoba formation. Shown where large enough to map separately. Description from source map: Concord Quadrangle (Bedrock) .

DSaqd - Assabet Quartz Diorite (Devonian to Silurian?)

Medium- to dark-gray, medium-grained, locally weakly foliated, quartz diorite. Composed chiefly of plagioclase, hornblende, quartz, and biotite. Locally contains granitic pegmatitic veins (DSap) with biotite grains up to 5 cm. Intrudes the Nashoba Formation. May be correlative with the Sharpner's Pond Diorite. Description from source map: Concord Quadrangle (Bedrock).

aqd - Assabet quartz diorite (Carboniferous)
Medium- to dark gray medium-grained, vaguely foliated rock composed of andesine, hornblende, quartz and biotite. Contains considerable apatite and some sphene and hematite. On weathered

surface biotite is altered to a bronze red. Description from source map: Hudson and Maynard Quadrangles.

DOsic - Sudbury Valley Igneous Complex (Devonian to Ordovician?)

This igneous complex is made of several phases believed to be contemporaneous. Lithologies are intermixed at sub-mapping scale:

1.) Granite: Medium- to dark-gray, medium- to coarse-grained, granite to granodiorite. Composed chiefly of altered plagioclase, potassium feldspar, quartz, hornblende, and ±biotite. Biotite flakes and occasional large (>6 mm) grains of white feldspar may be prominent. Locally very rusty weathering.
2.) Diorite: Medium- to dark-greenish-gray, very fine-grained, massive and very hard, diorite. Composed mainly of hornblende, altered plagioclase and quartz.

Description from source map: Concord Quadrangle (Bedrock).

DZwgh - Weston Group, Hornblende Member (Neoproterozoic to Devonian)

Dull-greenish-black, very fine-grained rock consisting of hornblende, chlorite, epidote, and oligoclase with a well defined schistose foliation. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as ZDwgh.

DZwghb - Weston Group, Hornblende-Biotite Member (Neoproterozoic to Devonian)

Shiny-dark-gray to black, very fine-grained rock consisting of hornblende, biotite, and oligoclase with a well defined schistose foliation. Porphyroblasts of hornblende (1-2mm) common, folded veins (5 mm) of plagioclase and magnetite present. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as ZDwghb.

DZwgp - Weston Group, Plagioclase-Hornblende-Biotite Member (Neoproterozoic to Devonian)

Gray-banded with salt-and-pepper coloration, fine-grained, well foliated rock. Composed of oligoclase, hornblende and biotite. Fine banding of plagioclase and mafic minerals (1-4mm). Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as ZDwgp.

DZwgm - Weston Group, Mylonitized Member (Neoproterozoic to Devonian)

Fine- to very fine-grained mylonitized rocks of the Weston Group. Epidote, chlorite, and quartz observed as alteration products. Fibrous calcite veins with crack and seal structures evident. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as ZDwgm.

Sls - Lexington Suite (Silurian)

Suite of rocks including: medium-gray, medium- to very coarse-grained, quartz-bearing, hornblende-biotite diorites and minor felsic rocks. Description from source map: Concord Quadrangle (Bedrock).

Sgr - Sudbury Granite (Silurian?)

Characteristically salmon-pink, medium- to coarse-grained, massive and non-foliated, granite. Commonly rusty weathering. Composed of alkali feldspar, plagioclase, quartz, and accessory biotite. Intrudes the White Pond Diorite. Description from source map: Concord Quadrangle (Bedrock).

Sgrd - Sudbury Granite, Dark Phase (Silurian?)

Dark-gray and pink, medium- to coarse-grained, massive and non-foliated, granite to granodiorite. Commonly rusty weathering. Description from source map: Concord Quadrangle (Bedrock).

Sgrm - Sudbury Granite, Mixed Phase (Silurian?)

A mixed phase of a white to pink, medium- to coarse-grained, massive and non-foliated, granite and the other phases of Sudbury Granite (Sgr and Sgrd) intermixed at a sub-mapping scale. Description from source map: Concord Quadrangle (Bedrock).

SZfhg - Fiske Hill Granite (Neoproterozoic to Silurian)

Gray-pink, medium-grained, inequigranular, biotite-bearing granite with white plagioclase and pink-orange microcline. Commonly seen as cataclastites and fault breccias. Description from source map: Concord Quadrangle (Bedrock).

Age now recognized to be Neoproterozoic to Silurian (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as ZSfhg.

bd - Basic dike (age unknown)

Location of small basic dike. Description from source map: Hudson and Maynard Quadrangles.

Basic dikes are represented in the GRI digital geologic-GIS data in the Point Geologic Units data layer.

Odgd - Draper Gabbro-Diorite (Ordovician?)

Gray-green, medium to coarse-grained, hornblende-bearing gabbro-diorite with areas of a mottled greenish-gray coloration and small clusters of chalky, greenish-white plagioclase grains visible. May be contemporaneous with Boston Post Diorite (bpd). Description from source map: Concord Quadrangle (Bedrock).

OCnu - Nashoba Formation, undifferentiated (Cambrian to Ordovician)

Medium- to dark-gray, fine- to coarse-grained, layered and well foliated, muscovite-biotite gneiss and schist. Composed chiefly of plagioclase, quartz, muscovite, and biotite. May locally contain potassium feldspar, sillimanite, garnet, and magnetite. Many exposures contain intrusions of Andover Granite and pegmatite. Description from source map: Concord Quadrangle (Bedrock).

Cn - Nioshoba formation (Carboniferous)
Predominantly light-gray to medium-gray medium-grained biotite paragneiss. Unit Cn, composed chiefly of quartz, biotite and sodic plagioclase (generally albite oligoclase) and containing minor but locally considerable amounts of orthoclase, garnet, sillimanite, and magnetite. Contains numerous interbedded layers of amphibolite schist (COna and Cons), hornblende gneiss, variably feldspathized quartzite beds that range in thickness from a fraction of an inch to many feet, and a few beds of marble. Most exposures contain some igneous material as small dikes, intrusive sheets or irregular masses of granite, aplite or pegmatite (COnp). Description from source map: Hudson and Maynard Quadrangles.

Age now recognized to be Cambrian to Ordovician (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as COu.

OCnbh - Nashoba Formation, Balls Hill Gneiss (Cambrian to Ordovician)

Light- to medium-gray, fine- to coarse-grained, layered and well foliated, quartzo-feldspathic gneiss. Composed chiefly of plagioclase, quartz, and biotite. Named for Balls Hill in Concord. Description from source map: Concord Quadrangle (Bedrock).

Age now recognized to be Cambrian to Ordovician (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as COnbh

.

OCna - Nashoba Formation, amphibolite (Cambrian to Ordovician)

Dark-greenish-gray, fine- to medium-grained, hornblende-plagioclase dominated, amphibolite found in the Nashoba Formation (OCnu). Shown separately where possible at this scale. Description from source map: Concord Quadrangle (Bedrock).

am - Nioshoba formation amphibolite (Carboniferous)
Interbedded layers of amphibolite schist. Description from source map: Hudson and Maynard Quadrangles.

Age now recognized to be Cambrian to Ordovician (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as COna.

OCns - Nashoba Formation, schist (Cambrian to Ordovician)

Rusty, dark-gray to black, sulfidic, muscovite, biotite schist. Mapped separately when possible at this scale within the Nashoba Formation (OZnu). Description from source map: Concord Quadrangle (Bedrock).

Age now recognized to be Cambrian to Ordovician (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as Cons.

OCnp - Nashoba Formation, pegmatite (Cambrian to Ordovician)

p - Nioshoba formation, pegmatite (Carboniferous)
Exposures (of OZnu) contain some igneous material as small dikes, intrusive sheets or irregular masses of granite, aplite or pegmatite. Description from source map: Hudson and Maynard Quadrangles.

Age now recognized to be Cambrian to Ordovician (as per personal communication with source map author Chris Hepburn).

The unit was previously denoted as COnp.

OCm - Marlboro Formation (Cambrian to Ordovician or Older?)

Commonly light- to dark-greenish-gray, fine- to medium-grained, massive to well foliated, schistose amphibolite. Mainly composed of hornblende, plagioclase, and biotite. Epidote present in many exposures. Mylonitized locally into very thinly laminated alternating layers of creamy-white to dull-olive-gray, sheared rock that contains epidote and quartz nodules and veins. Minor cream-colored quartzite lenses to 2 meters in length. Sheared marble observed at one exposure. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as Com.

OCmjs - Marlboro Formation, Jupiter Ridge Schist Member (Cambrian to Ordovician or Older?)

Rusty, dark-gray to black, sulfidic, muscovite-biotite schist with minor accessory pyrite and/or marcasite. Found as a lense within the Marlboro Formation (Com). Named for Jupiter Ridge, Lincoln. Description from source map: Concord Quadrangle (Bedrock).

The unit was previously denoted as COmjs.

Zwm - Westboro Formation, Mylonite (Neoproterozoic?)

Interlayered light-tan to light-gray and dark-greenish-gray, very fine-grained, thinly laminated, mylonitized quartzite. Commonly rusty weathered. Description from source map: Concord Quadrangle (Bedrock).

Age older than ~600 Ma to as old as ~1,000 Ma (as per personal communication with source map author Chris Hepburn).

UNKkgu - Kendall Green Ultramylonite (age unknown)

Dark-gray to pale-green, very fine-grained, finely layered ultramylonite with thin layers of calcite. Psuedotachylite present locally. Multiple protoliths likely. Description from source map: Concord Quadrangle (Bedrock).

Age of unit is unknown.

UNKchm - Cranberry Hill Mylonite (age unknown)

Very dark gray-green, fine-grained, mylonitized mafic rock containing meter-sized stretched pods of epidote and calcite and coticule veins up to 3 cm long. Mapped separately due to uncertainty of the protolith. Description from source map: Concord Quadrangle (Bedrock).

Age of unit is unknown.

Zhm - Haywood Brook Mylonite (Neoproterozoic?)

Dark-gray with prominent pinkish-white layers, fine- to medium-grained, blastomylonite. Composed chiefly of hornblende, and plagioclase with quartz, muscovite ±biotite locally containing garnet. Mapped separately due to uncertainty of the protolith. Description from source map: Concord Quadrangle (Bedrock).

Zv - Mafic to Felsic Tectonite (Neoproterozoic)

Dull-black and dark-gray to shiny-black, commonly rusty weathering, fine-grained, unfoliated gabbro-diorite to weakly foliated tectonite with a sugary texture. Secondary calcite common. Adapted after Zen et al. (1983). Description from source map: Concord Quadrangle (Bedrock).

Bedrock outcrops and areas of abundant outcrop or shallow bedrock

In areas of shallow bedrock, surficial materials are less than 5-10 ft thick. Small outcrops too numerous to map individually. Description from source map: Concord Quadrangle (Bedrock).

Bedrock outcrops, as well as areas of shallow bedrock, are included the GRI digital geologic-GIS data as the Outcrops and Shallow Bedrock data layer.

Ancillary Source Map Information

The following sections present ancillary source map information associated with the source maps used for the GRI Digital Bedrock Geologic-GIS Map of Minute Man National Historical Park, Massachusetts (MIMA) (*GRI MapCode MIMA*).

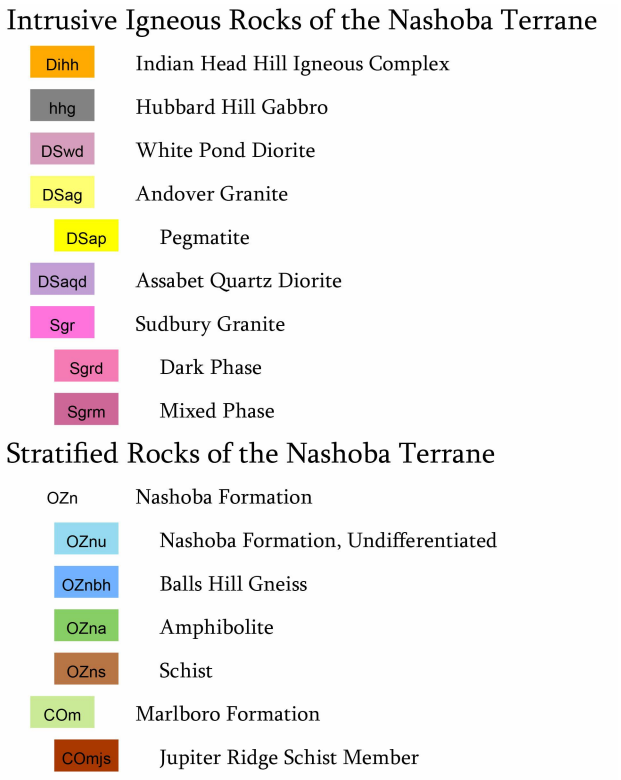
Concord Quadrangle (Bedrock) (Langford and Hepburn, 2007)

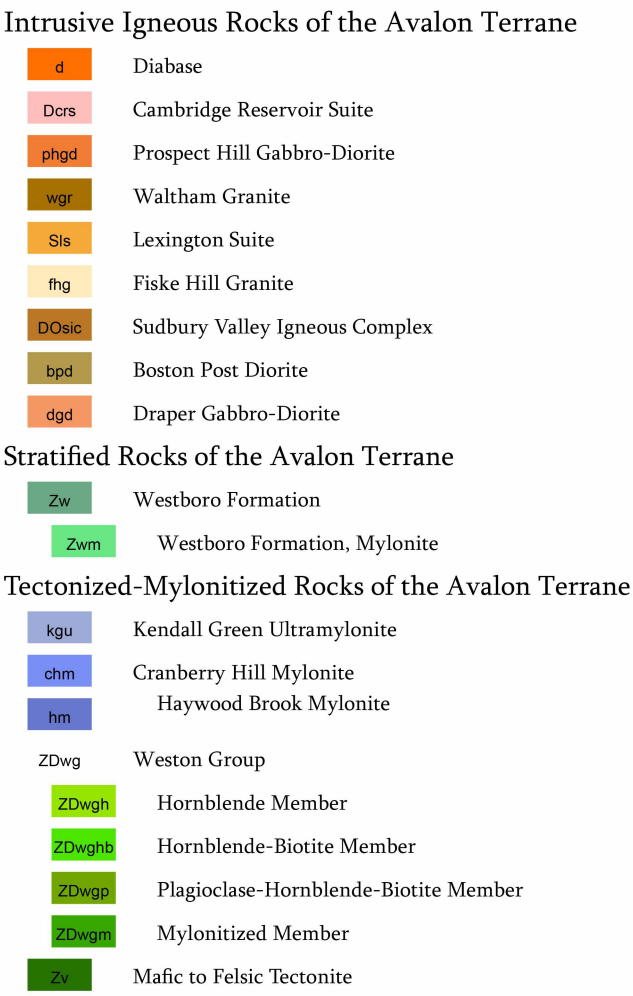
Langford, C.D., and Hepburn, C.J., 2007, Preliminary Bedrock Geologic Map of the Concord Quadrangle, Massachusetts: Boston College, Master's Thesis, scale 1:24,000. (*GRI Source Map ID 74982*).

Prominent graphics and text associated with this source.

Legend (Unit Explantion)

The following is the unit explanation (listing) present on the source map. The listing order is based on the geologic terrane (Nashoba Terrane or Avalon Terrane) and rock type (igneous rocks, stratified rocks and tectonized-mylonitized rocks) and not fully on unit age.

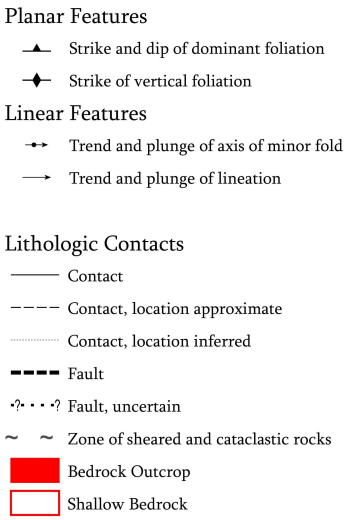




Graphic from source map: Concord Quadrangle (Bedrock).

Unit Zw, although present on the above unit legend, was not actually present (i.e., mapped) on the source map, and thus is not present in the GRI digital geologic-GIS data.

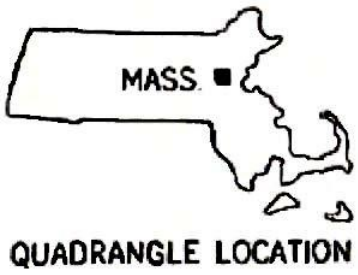
Legend (Map Symbols)



Graphic from source map: Concord Quadrangle (Bedrock).

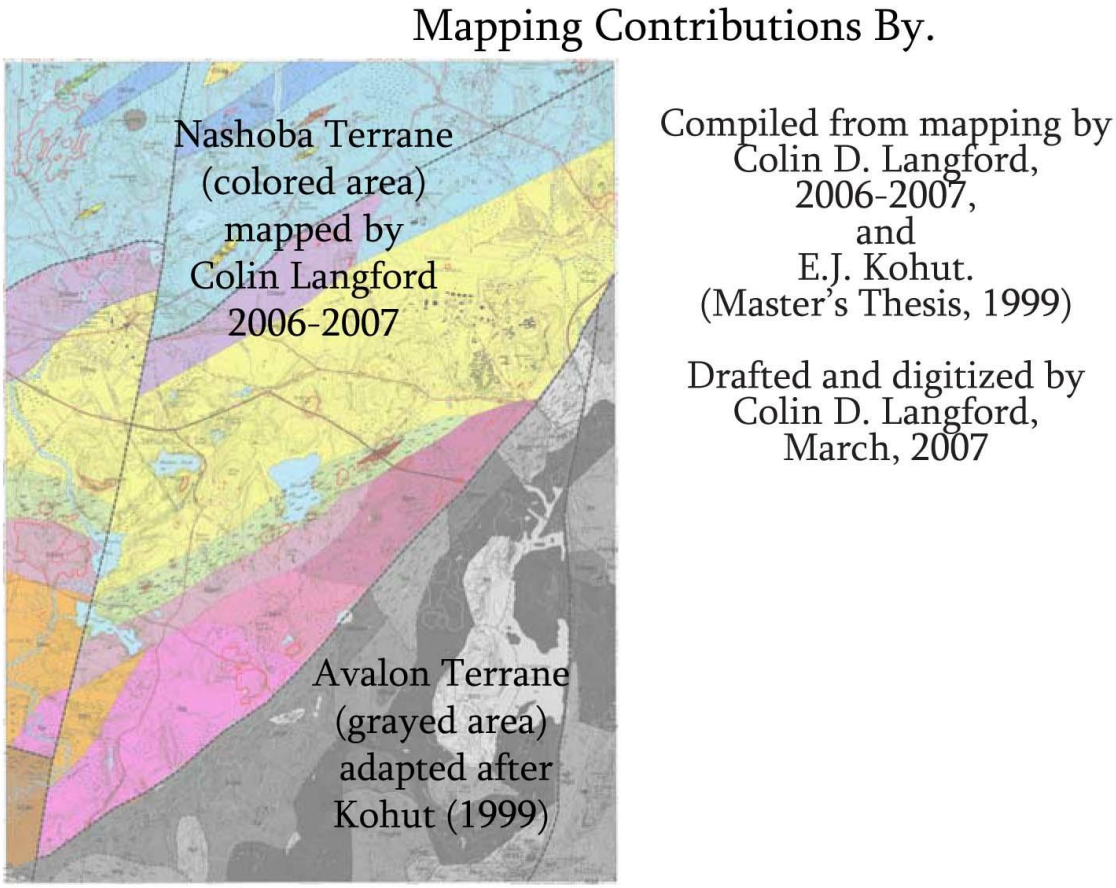
Although the source publication legend indicates that both trend and plunge of lineation and strike of vertical foliation features are present neither were found on the actual map.

Index Map



Graphic from source map: Concord Quadrangle (Bedrock).

Mapping Contributions



Graphic from source map: Concord Quadrangle (Bedrock).

Map References

Emerson, B.K., 1917, Geology of Massachusetts and Rhode Island: U.S. Geological Survey Bulletin 597, 289 p.

Hepburn, J.C., Dunning, G.R., and Hon, R, 1995, Geochronology and regional tectonic implications of Silurian deformation in the Nashoba terrane, southeastern New England, U.S.A., in Hibbard, J.P., van Staal, C.R. and Cawood, P.A., eds., Current Perspectives in the Appalachian-Caledonian Orogen: Geological Association of Canada, Special Paper 41, p.349-366.

Hill, M. D., Hepburn, J. C., Collins, R. D., and Hon, R., 1984, Igneous rocks of the Nashoba Block, eastern Massachusetts in Hanson, Lindley S. [editor] Geology of the Coastal Lowlands; Boston, MA to Kennebunk, ME: Salem State College, Dept. of Geological Sciences, Salem, MA, New England Intercollegiate Geological Conference Guidebook v. 76, p. 61-80.

Kohut, Edward, J., 1999, The Bedrock Geology of the Weston-Lexington Area, Southeastern New England Avalon and Nashoba Terranes: Unpub. M.S. Thesis, Boston College, 159 pp.

Zartman, R. E., and Marvin, R.F., 1991, Radiometric Ages of Rocks in Massachusetts, in Hatch, N.L. Jr., ed., The Bedrock Geology of Massachusetts: U.S. Geological Survey Professional Paper 1366

E-J, p. J1-J19.

Zen, E an, ed., Goldsmith, R., Ratcliffe, N.M., Robinson, P. and Stanley, R.S., compilers, 1983, Bedrock geologic map of Massachusetts: United States Geological Survey, 1:250 000, 1 sheet.

Text from source map: Concord Quadrangle (Bedrock).

Hudson and Maynard Quadrangles (Bulletin 1038)

Hansen, W.R., 1956, Geology and Mineral Resources of the Hudson and Maynard Quadrangles, Massachusetts (plate 1: Map and Sections Showing Bedrock Geology): U.S. Geological Survey, Bulletin 1038, plate 1 of 3, scale 1:24,000. (*GRI Source Map ID 2772*).

Only a 2.5' by 2.'5 area in the northeastern corner of the Maynard Quadrangle was used.

No graphics were captured from this map as these either pertained to the full map extent (e.g., listing of map units), or were not in the extent of the map area used (e.g., cross sections).

Previous GRI (Bedrock) Map Unit Listing

Bedrock units are presented below in the order presented on the Concord Quadrangle (Bedrock) source map. As previously mentioned, this order is based on the geologic terrane (Nashoba Terrane or Avalon Terrane) and rock type (igneous rocks, stratified rocks and tectonized-mylonitized rocks) and not entirely on unit age. This order of units is also the order of units (for units actually within the park) presented in the Geologic Resources Inventory (GRI) Report for Minute Man National Historical Park (Thornberry-Ehrlich, 2017). Units are listed below with their assigned unit symbol and unit name (e.g., Dihh - Indian Head Hill Igneous Complex). As also previously mentioned in the (Bedrock) Map Unit List section (see section for additional information), several (bedrock) unit symbols were also changed from the previous version of this map and the GRI report. If a unit symbol has been changed the legacy symbol appears in parentheses in the list below. Unit symbol changes are also denoted with that unit's description (see (Bedrock) Map unit Descriptions section).

Nashoba Terrane

Intrusive Igneous Rocks

Dihh – Indian Head Hill Igneous Complex
UNKhhg – Hubbard Hill Gabbro
DSwd – White Pond Gabbro
DSag – Andover Granite
DSap – pegmatite
DSaqd – Assabet Quartz Diorite
Sgr – Sudbury Granite
Sgrd – Sudbury Granite, Dark Phase
Sgrm – Sudbury Granite, Mixed Phase

Intrusive dikes of Unknown Age

bd - Basic dike*

Stratified Rocks

OCnu (COnu) – Nashoba Formation, undifferentiated
OCnbh (COnbh) – Nashoba Formation, Balls Hill Gneiss
OCna (COna) – Nashoba Formation, amphibolite
OCns (Cons) – Nashoba Formation, schist
OCnp (COnp) – Nashoba Formation, pegmatite

OCm (Com) – Marlboro Formation
OCmjs (COmjs) – Marlboro Formation, Jupiter Ridge Schist Member

Avalon Terrane

Intrusive Igneous Rocks

MZd – diabase
Dcrs – Cambridge Reservoir Suite
DSphgd – Prospect Hill Gabbro-Diorite
PZwgr (MZwgr) – Waltham Granite
Sls – Lexington Suite
SZfhg (ZSfhg) – Fiske Hill Granite
DOsic – Sudbury Valley Igneous Complex
Odgd – Draper Gabbro-Diorite

Stratified Rocks

Zwm – Westboro Formation, Mylonite

Tectonized-Mylonitized Rocks of the Avalon Terrane

UNKkgu – Kendall Green Ultramylonite
UNKchm – Cranberry Hill Mylonite
Zhm – Haywood Brook Mylonite
DZwgh (ZDwgh) – Weston Group, Hornblende Member
DZwghb (ZDwghb) – Weston Group, Hornblende-Biotite Member
DZwgp (ZDwgp) – Weston Group, Plagioclase-Hornblende-Biotite Member
DZwgm (ZDwgm)– Weston Group, Mylonitized Member
Zv – Mafic to Felsic Tectonite

* Small basic dikes (unit bd) are represented in the GRI digital geologic-GIS data in the Point Geologic Units data layer. The unit was not present on the source map legend.

Geologic Resources Inventory Report Citation:
Thornberry-Ehrlich, T. L., 2017, Minute Man National Historical Park: Geologic Resources Inventory Report: Natural Resources Report NPS/NRSS/GRD/NRR --2017/1523. National Park Service, Fort Collins, Colorado.

Digital Surficial Geologic-GIS Map of Minute Man National Historic Site

Map Unit List

The surficial geology units present in the Digital Surficial Geologic-GIS Map of Minute Man National Historic Site, Massachusetts (*GRI MapCode MIMA_surficial*) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qaf - Artificial fill). Units are listed from youngest to oldest. Information about each geologic unit is also presented in the Geologic Unit Information (MIMAUNIT_surficial) table included with the GRI geologic-GIS data.

Quaternary Period
Postglacial Deposits
- Qaf – Artificial fill*
- Qal – Floodplain alluvium
- Qsw – Swamp deposits

Glacial Stratified Deposits
- Qsdc – Glacial stratified deposits, coarse
- Qsdf – Glacial stratified deposits, fine

Glacial Till Deposits
- Qt – Thin till
- Qtt – Thick till

pre-Quaternary
- br - Bedrock outcrop

* Although unit Qaf is listed as a Postglacial Deposit, in the GRI digital geologic-GIS data the unit areas are their own GIS data layer.

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

Qaf - Artificial fill (Quaternary)

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. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qal - Floodplain alluvium (Quaternary)

Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, beneath the floodplains of modern streams. The texture of alluvium commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. Along smaller streams, alluvium is commonly less than 5 ft thick. The most extensive deposit of alluvium on the map is along the Charles, Assabet, and Concord Rivers where the texture is predominantly sand, fine gravel, and silt, and total thickness is as much as 25 ft. Alluvium typically overlies thicker glacial stratified deposits. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qsw - Swamp deposits (Quaternary)

Organic muck and peat that contain minor amounts of sand, silt, and clay, stratified and poorly sorted, in kettle depressions or poorly drained areas. Most swamp deposits are less than about 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Glacial Stratified Deposits

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in particle size diagram) 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 map, gravel, sand and gravel, and sand deposits are not differentiated and are shown as Coarse Deposits where they occur at land surface. Fine Deposits also are shown where they occur at land surface. Textural changes occur both areally and vertically, however subsurface textural variations are not shown on this interim map. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qsdc - Glacial stratified deposits, coarse (Quaternary)

Gravel deposits composed mainly of gravel-sized clasts; cobbles and boulders predominate; minor amounts of sand within gravel beds, and sand comprises 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 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 composed mainly of very coarse to fine sand, commonly in well-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. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qsdf - Glacial stratified deposits, fine (Quaternary)

Very fine sand, silt, and clay that occurs 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. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qt - Thin till (Quaternary)

Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; in areas where till is generally less than 10-15 ft thick and including areas of bedrock outcrop where till is absent. 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. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarser grained crystalline rocks. Fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut River lowland, marble in the western river valleys, and fine-grained schists in upland areas. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Qtt - Thick till (Quaternary)

Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders at the surface; in the shallow subsurface, compact, nonsorted matrix of silt, very fine sand, and some clay containing scattered small gravel clasts in areas where till is greater than 10-15 ft thick, chiefly in drumlin landforms in which till thickness commonly exceeds 100 ft (maximum recorded thickness is 230 ft). Although upper till is the surface deposit, the lower till constitutes the bulk of the material in these areas. Lower till is moderately to very compact, and is commonly finer grained and less stony than upper till. An oxidized zone, the lower part of a soil profile formed during a period of interglacial weathering, is generally present in the upper part of the lower till. This zone commonly shows closely spaced joints that are stained with iron and manganese oxides. Description from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

br - Bedrock outcrop

Area of abundant outcrop or shallow bedrock. No additional unit description provided. Unit present on source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Ancillary Source Map Information

The following section presents ancillary source map information associated with the source map used for the GRI Digital Surficial Geologic-GIS Map of Minute Man National Historical Park, Massachusetts (MIMA) (*GRI MapCode MIMA_surficial*).

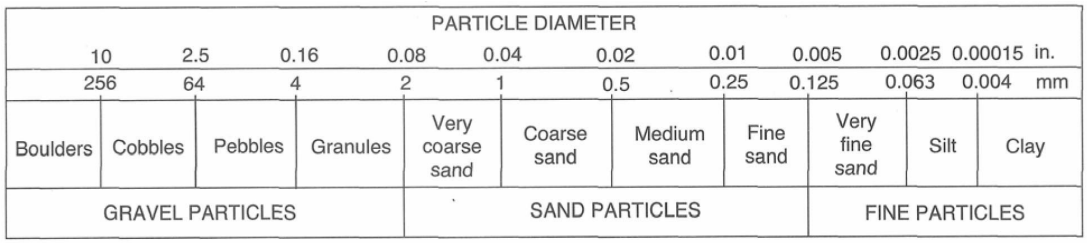
Clinton-Concord-Grafton-Medfield 12 Quadrangle Area (OF 2006-1260A)

Stone, J.R., and Stone, B.D., 2006, Surficial Geologic Map of the Clinton-Concord-Grafton-Medfield 12 Quadrangle Area in East Central Massachusetts, U.S. Geological Survey, Open File Report OF-2006-1260A, 1:50,000 scale. (*GRI Source Map ID 74750).*

As previously mentioned, only data within the extent of the Concord 7.5' quadrangle, as well as a 2.5' by 2.'5 area in the northeastern corner of the Maynard 7.5' quadrangle were used for the GRI digital surficial geologic-GIS map.

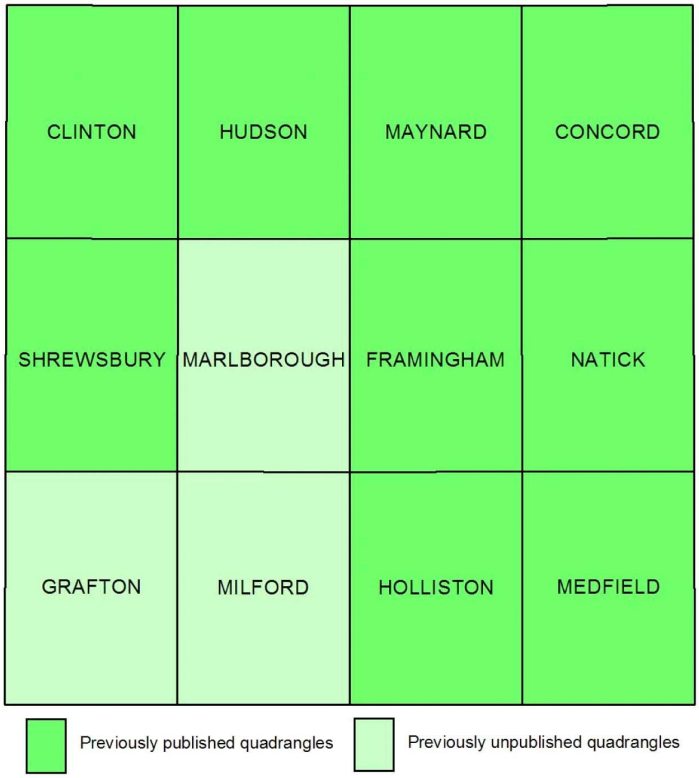
Prominent graphics and text relevant to the extent of the source map used.

Grain Size Classification



Graphic from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Index Map

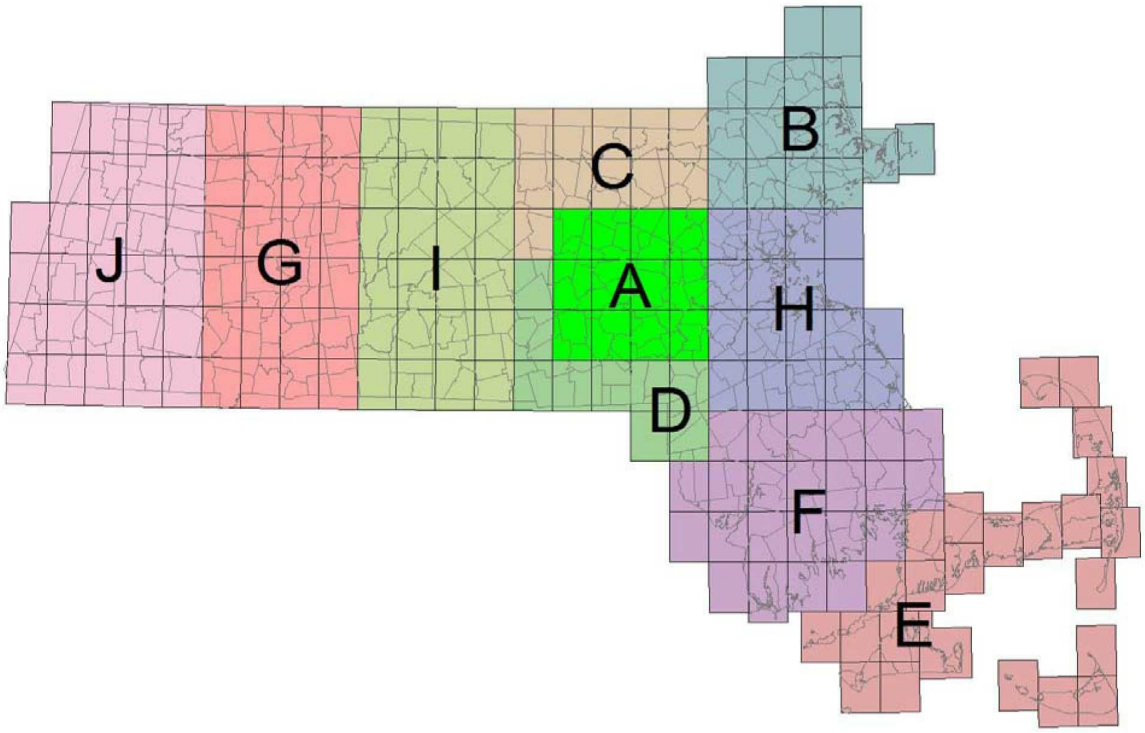


7.5-minute quadrangles in this compilation

Graphic from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Only data within the extent of the 7.5' Concord quadrangle, and a 2.5' by 2.'5 area in the northeastern corner of the Maynard 7.5' quadrangle was used.

Compilation Areas in Massachusetts



The area applicable to the source digital data presented in the previous figure is area A in this figure.

Graphic from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

Quadrangle Sources

Concord Quadrangle

Map units were reproduced from Koteff (1964). Glacial Stratified Deposits in this quadrangle include deposits of glacial lakes Sudbury and Concord, and other smaller valley deposits. Fine-grained glacial stratified deposits at land surface include lake-bottom deposits of glacial Lakes Sudbury and Concord (unit Qlsb and Qlcb of Koteff, 1964); these units have been extended beneath adjacent water bodies and postglacial deposits on this map. Thick till areas shown on this map were inferred from photographic image and topographic analysis and drumlin symbols shown by Koteff (1964).

Maynard Quadrangle

Map units were produced from Hansen (1956). Glacial Stratified Deposits in this quadrangle include various glacial lake and stream deposits. Fin-grained glacial stratified deposits at land surface include lake-bottom deposits of Lake Sudbury (parts of unit Qsg of Hansen,m 1956); this unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Drumlin till unit was reproduced from the published map; other areas of thick till were inferred from photographic image and topographic analysis.

Text from source map: Clinton-Concord-Grafton-Medfield 12 Quadrangle Area.

GRI Digital Data Credits

This document was developed and completed by Stephanie O'Meara (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Jim Chappell (Colorado State University). Initial document development by Philip Reiker and Georgia Hybels (NPS GRD, Lakewood, Colorado), and Stephanie O'Meara.

The information in this document was compiled from the GRI source map, and intended to accompany the digital geologic-GIS map and other digital data for Minute Man National Historical Park, Massachusetts (MIMA) developed by Stephanie O'Meara and Sarah Lowe (Colorado State University; see the GRI Digital Maps and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps. Initial GRI digital geologic-GIS data production by Philip Reiker, Stephanie O'Meara and Dave Green (Colorado State University).

GRI finalization by Stephanie O'Meara (Colorado State University).

GRI program coordination provided by Jason Kenworthy (NPS GRD, Lakewood, Colorado). Initial coordination and scoping provided Bruce Heise and Tim Connors (NPS GRD, Lakewood, Colorado)