U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Saint-Gaudens National Historical Park

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Saint-Gaudens National Historical Park

saga_bedrock_geology.pdf

Version: 9/29/2020

Geologic Resources Inventory Map Document for Saint-Gaudens National Historical Park

Table of Contents

Geologic Resources Inventory Map Document

Saint-Gaudens National Historical Park, New Hampshire

Document to Accompany Digital Geologic-GIS Data

saga_bedrock_geology.pdf

Version: 9/29/2020

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Saint-Gaudens National Historical Park, New Hampshire (SAGA).

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 all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

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

4) **Map Unit Descriptions** – Descriptions for all bedrock geologic map units. If a unit is present on multiple source maps the unit is listed with its source geologic unit symbol, unit name and unit age followed by the unit's description for each source map.

5) **Geologic Cross Sections** – Geologic cross section graphics with source geologic cross section abbreviations.

6)**Photographs** – Information pertaining to photograph localities present in the GRI digital geologic-GIS data.

7) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may include a stratigraphic column, index map, map legend and/or

map notes.

8) **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:

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About the NPS Geologic Resources Inventory Program

Background

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. 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 GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

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:

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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-GIS maps for Saint-Gaudens National Historical Park, New Hampshire (SAGA):

Digital Bedrock Geologic-GIS Map of the Saint-Gaudens National Historical Park and Vicinity, New Hampshire (*GRI MapCode SAGA*)

The above map was compiled from the individual component GRI digital geologic-GIS maps listed below. The source map for each map is also listed with each component map.

Digital Bedrock Geologic-GIS Map of the Hartland and North Hartland 7.5' Quadrangles, New Hampshire (*GRI MapCode HANH*)

Walsh, G.J., 2016, Bedrock geologic map of the Hartland and North Hartland Quadrangles, Windsor County, Vermont, and Sullivan and Grafton Counties, New Hampshire: U.S. Geological Survey, Scientific Investigations Map SIM-3361, scale 1:24,000 (Hartland and Hartland North Quadrangles (Bedrock)). (*GRI Source Map ID 76011*).

The GRI used the full extent of the source map presented above, and captured all geologic features within its extent. Although "area water" (rivers and water bodies represented as an area (i.e., polygon)) is present in the source GIS data these were not included in the GRI digital geologic-GIS data. Their omission was primarily because the source map for the Mount Ascutney map did not have area water (see map and its source map below). However, feature attribution that denotes subaqueous inference is present in the GRI digital geologic-GIS data where applicable.

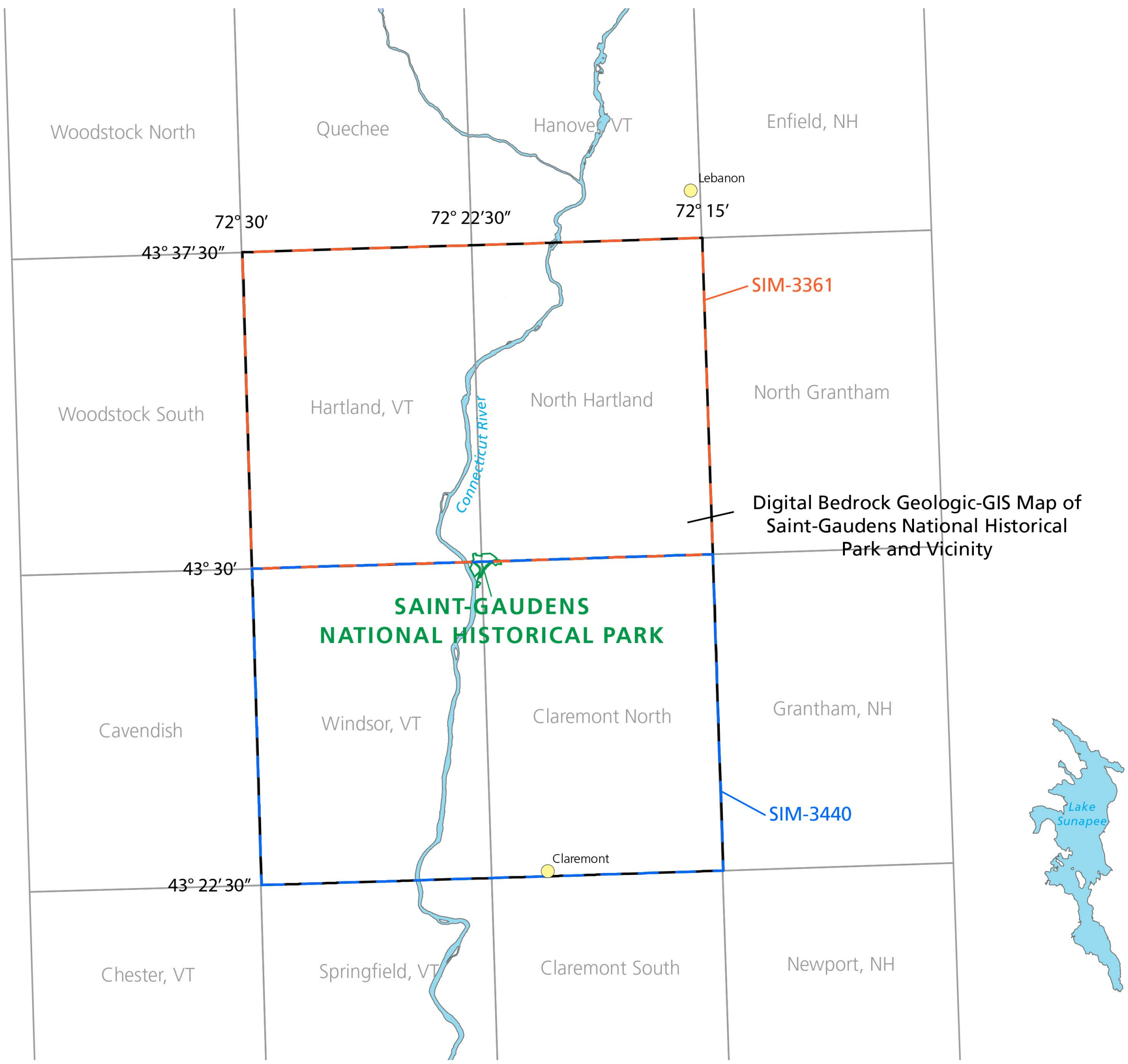
Digital Bedrock Geologic-GIS Map of the Mount Ascutney 7.5'x15' Quadrangle, New Hampshire (*GRI MapCode MTAS*)

Walsh, G.J., et.al., 2020, Bedrock geologic map of the Mount Ascutney 7.5- x 15-Minute Quadrangle, Windsor County, Vermont and Sullivan County, New Hampshire: U.S. Geological Survey, Scientific Investigations Map SIM-3440, scale 1:24,000 (Mount Ascutney 7.5'x15' Quadrangle (Bedrock)). (*GRI Source Map ID 76318*).

The GRI used the full extent of the source map presented above, and captured all geologic features within its extent. Although the source GIS data didn't include "area water" (rivers and water bodies represented as an area (i.e., polygon)), linear features inferred within/beneath water did have attribution denoting this, and this information is retained in the GRI digital geologic-GIS data.

Index Map

The following index map displays the extents of the GRI digital geologic-GIS maps produced for Saint-Gaudens National Historical Park (SAGA). The dashed orange line represents the extent of Scientific Investigation Map SIM-3361 which was used to produced the Digital Bedrock Geologic-GIS Map of the Hartland and North Hartland 7.5' Quadrangles, New Hampshire (*GRI MapCode HANH*) and the dashed blue line represents Scientific Investigation Map SIM-3440 which was used to produce the Digital Bedrock Geologic-GIS Map of the Mount Ascutney 7.5'x15' Quadrangle, New Hampshire (*GRI MapCode MTAS*). The dashed black line represents the extent of the GRI compiled map: Digital Bedrock Geologic-GIS Map of the Saint-Gaudens National Historical Park and Vicinity, New Hampshire (*GRI MapCode SAGA*). The boundary for Saint-Gaudens National Historical Park (as of September, 2020) is outlined in green.



Index Map by Jake Suri (Colorado State University).

Map Unit List

The bedrock geologic units present in the digital geologic-GIS data produced for Saint-Gaudens National Historical Park, New Hampshire (SAGA) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Kg - Biotite granite). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (SAGAUNIT) table included with the GRI geologic-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description.

Mesozoic Era

Cretaceous Period

Kg - Biotite granite
Ka - Aplite dikes
Ks - Syenite
Ksm - Medium-grained syenite to quartz syenite
Kd - Mafic dikes
Kt - Trachyte dikes
Kfd - Spherulitic felsic dikes
Kch - Hornfels, inner metamorphic zone
Kh - Hornfels, outer metamorphic zone
Kspb - Syenite, plutonic breccia
Kv - Trachyte to rhyolite and volcanic breccia
Kgd - Gabbro and diorite

Mesozoic Era

Msz - Silicified zone

Mesozoic and Paleozoic Eras

Cretaceous and Devonian Periods

KDq - Quartz veins

Paleozoic Era

Devonian Period

Dg - Granite
Dp - Pegmatite
Dgm - Gile Mountain Formation, Meetinghouse Slate Member
DSm - Melange
Dl - Littleton Formation, schist member
Dlcg - Littleton Formation, metaconglomerate member
Dlc - Littleton Formation, coticule and ironstone member
Dlq - Littleton Formation, interbedded quartzite and schist member
Dgq - Gile Mountain Formation, feldspathic quartzite, granofels, and metapelite member
Dgqs - Gile Mountain Formation, gray quartzite and metapelite member
Dgqc - Gile Mountain Formation, quartzite, conglomerate, and metapelite member
Dgg - Gile Mountain Formation, greenstone member

Dgqq - Gile Mountain Formation, quartzite, conglomerate, and metapelite member, white quartzite to quartz-pebble conglomerate
Dgqcm - Gile Mountain Formation, quartzite, conglomerate, and metapelite member, white and gray calcite marble
Dgh - Gile Mountain Formation, hornblende fascicle schist member
Dgf - Gile Mountain Formation, felsic gneiss and quartzose granofels member
Dgab - Gile Mountain Formation, ankeritic biotite schist member

Devonian and Silurian Periods
DSfm - Fitch Formation, marble member
DSfgr - Fitch Formation, calc-silicate granofels member
DSfs - Fitch Formation, laminated schist member
DSfg - Fitch Formation, greenstone member
DSf - Fitch Formation, gray granofels and schist member
DScd - Metadiabase dike
DSwl - Waits River Formation, limestone and schist member
DSws - Waits River Formation, gray phyllite and schist member
DSwq - Waits River Formation, gray phyllite and schist member, quartzite and granofels
DSwv - Waits River Formation, laminated schist and granofels member
DSwf - Waits River Formation, felsic gneiss and quartzose granofels member
DSwvp - Waits River Formation, porphyritic schist and granofels member
DSwg - Waits River Formation, large-garnet and hornblende garbenschiefer schist member
DSwhg - Waits River Formation, hornblende-plagioclase gneiss member
DSwa - Waits River Formation, amphibolite and greenstone member
DSwss - Waits River Formation, sulfidic schist member
DSn - Northfield Formation, schist member

Silurian Period
Scq - Clough Quartzite, metaconglomerate and quartzite member
Scs - Clough Quartzite, rusty muscovite schist member
Scms - Clough Quartzite, muscovite schist member
Ss - Shaw Mountain Formation

Ordovician Period
Oqd - Quartz diorite of the Lebanon dome
Op - Partridge Formation, sulfidic schist member
Opa - Partridge Formation, sulfidic schist member, amphibolite
Opq - Partridge Formation, sulfidic schist member, quartzite beds
Opp - Partridge Formation, plagioclase studded schist member
Ogd - Granodiorite, trondhjemite, and tonalite of the Sugar River pluton
Oa - Ammonoosuc Volcanics, heterogenous volcanic member
Oas - Ammonoosuc Volcanics, sulfidic schist member
Oaf - Ammonoosuc Volcanics, metafelsite member
Oafa - Ammonoosuc Volcanics, bimodal metavolcanic rocks member
Oarr - Ammonoosuc Volcanics, rusty sulfidic granofels member
Oarg - Ammonoosuc Volcanics, lapilli tuff member
Oag - Ammonoosuc Volcanics, felsic granofels member
Oaa - Ammonoosuc Volcanics, greenstone and amphibolite member
Ochg - Cram Hill Formation, greenstone member
Ochv - Cram Hill Formation, felsic and mafic volcaniclastic rocks member
Ochq - Cram Hill Formation, quartzite member
Ot - Trondhjemite and tonalite
Otp - Plainfield tonalite
Ontd - Trondhjemite gneiss

Ordovician and Cambrian Periods
OCmhfs - Moretown Formation, hornblende fascicle schist member
OCmb - Moretown Formation, black schist member
OCmgt - Moretown Formation, garnet schist and granofels
OCmrq - Moretown Formation, quartzite member
OCu - Talc-carbonate schist
OCmfs - Moretown Formation, green schist and granofels member
OCmfsc - Moretown Formation, green schist and granofels member, coticule beds
OCma - Moretown Formation, amphibolite

Mesoproterozic Era
Y1bm - Baileys Mills tonalitic gneiss
Y1bmp - Baileys Mills plagioclase-phenocrystic tonalite gneiss
Ycfs - Cavendish Formation, feldspathic schist or granofels
Ycm - Cavendish Formation, marble
Ybg - Biotite-quartz-plagioclase-gneiss
Ya - Amphibolite
Y2rs - Quartz schist and gneiss

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. For each description, the source map's unit symbol, unit name and unit age are first presented. Its is worth noting that on the source maps the Fitch Formation is denoted as being both Devonian and Silurian in age, yet the unit symbols for units that are of this unit were only assigned an age unit symbol of "S" and not "DS". These units are referenced in the GRI digital geologic-GIS data with a "DS" to denoted the units are both Devonian and Silurian.

Kg - Biotite granite (Early Cretaceous)

Coarse-grained, locally medium-grained, predominantly homogeneous, biotite-quartz-microperthite-orthoclase-albite granite. At one time, it was correlated with the Conway Granite (Chapman and Chapman, 1940; Cox, 1987), but the Conway Granite was determined to be 30 to 50 million years older (Jurassic in age) by Eby and others (1992). The unit is distinguished from the syenite by the presence of coarse quartz crystals and noticeably less mafic accessory minerals. Similar to the syenite, it also weathers chalky white, but fresh surfaces reveal salmon-pink colored alkali feldspar crystals, milky white plagioclase, and clear (grayish) quartz with minor magnetite, biotite, and ±hornblende. The contact with the surrounding syenite is diffuse and transitional over several meters. At station 13051 (see GIS database) on the Mount Ascutney State Park summit road, the contact can be seen as transitional across a 3-m-wide zone. Within this zone, the granite is finer grained, but there are also pegmatitic zones (~30 cm thick) present with abundant quartz. These pegmatitic zones are not connected but concentrated in linear zones parallel to the strike of the contact. As the granite transitions into syenite, the rock becomes less quartz rich and richer in mafic minerals. The syenite in this zone is medium to coarse grained, and gradually coarsens farther away from the contact. Aplite dikes are more abundant in places within the syenite near the contact. At station 13111 (see GIS database), the granitic aplite dikes are curved and bifurcated, oriented in many different directions, and appear to be related to the intrusion of the granite. The granite occurs as a stock on the east side of Mount Ascutney and occurs as dikes that are generally less than 1 m thick in the country rock surrounding the pluton. Outcrop-scale dikes are shown by strike-and-dip symbols. The unit hosts three closely spaced abandoned quarries that are shown by one symbol on the south side of the mountain (Daly, 1903). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ka - Aplite dikes (Early Cretaceous)

Light-tan or pink, very fine grained, undifferentiated syenite to granite aplite dikes. Thirty outcrop-scale dikes are shown by strike-and-dip symbols, and dikes range from several centimeters up to 5.0 m thick. The dikes occur on Mount Ascutney and intrude the syenite (Ks), the granite (Kg), the gabbro and diorite (Kgd) and the hornfels (Kch). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ks - Syenite (Early Cretaceous)

Light-gray, dark-green to chalky white weathering to very light gray to rusty weathering, coarse-grained, locally porphyritic, biotite-hornblende-perthite syenite. Contains accessory magnetite and minor clinopyroxene (augite), fayalite, and quartz (Schneiderman, 1991). Perthite is locally sericitized. The rock contains accessory apatite, zircon, titanite, monazite, and magnetite (Schneiderman, 1991) and commonly contains xenoliths. Near the contact with the country rock (within ~400 m or less), large meterscale and smaller xenoliths of hornfels are common. At distances greater than 400 m from the contact, hornfels xenoliths are rare or absent. The most common xenoliths are black to dark-grayish-purple, porphyritic volcanic rock with white, coarse-grained, euhedral to subhedral feldspar crystals in an aphanitic fine-grained dark matrix. Originally called "basic segregations" by Daly (1903), they were later interpreted as xenoliths (Chapman and Chapman, 1940; Foland and others, 1985; Schneiderman, 1991). The xenoliths are commonly softball sized or smaller and angular to subrounded in shape. Areas with a very high density of xenoliths (up to 70 or 80 percent of the rock) are mapped separately as plutonic breccia (Kspb), most notably at Cascade Falls. Large (kilometer-scale) screens of volcanic rock are mapped separately within the syenite on the west side of Mount Ascutney. Dikes of syenite that contain xenoliths of gneiss of the Mount Holly Complex (for example, station MA-1536 in the GIS database) intrude the gabbro and diorite of the Little Ascutney stock (Kgd). Syenite occurs as the main stock of Mount Ascutney and occurs as dikes (generally less than 1 m thick) in the country rock surrounding the pluton. Outcrop-scale dikes are shown by strike and dip symbols. The unit hosts three abandoned quarries (Mower, Enwrighte, and Norcross) (Dale, 1909, 1923; Morrill and Chaffee, 1964). The quarried stone was called the "Windsor granite" or "Ascutney green" (Dale, 1909, 1923). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ksm - Medium-grained syenite to quartz syenite (Early Cretaceous)

Light-gray, white to very light gray weathering to rusty weathering, medium-grained, biotite-hornblende-perthite syenite to quartz syenite. Quartz content ranges from about 5 to 10 percent. The rock is characteristically finer grained than the surrounding host-rock syenite (Ks) into which it intruded. The contact with the coarse-grained syenite (Ks) is typically sharp, and some angular xenoliths of Ks were found within this unit. Locally, the unit contains volcanic xenoliths similar to the xenoliths within the coarse syenite. Generally, the unit contains less mafic minerals than the coarse-grained syenite, but locally exhibits mafic-rich zones with euhedral hornblende crystals. The unit contains abundant, large (meter-scale) lenses and irregular, interfingering patches of coarse syenite (Ks) and apparently intruded the coarse syenite via closely spaced dikes that interconnected and coalesced. The unit is mapped on the north side of Mount Ascutney and is well exposed at the Ascutney North summit. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kd - Mafic dikes (Cretaceous)

Kmd - Mafic dikes (Cretaceous)
Aphanitic, dark-gray to black, undifferentiated lamprophyre. camptonite, or diabase dikes. Dikes range in thickness from 0.1 to 2.5 meters (m) and may contain phenocrysts of biotite, amphibole, pyroxene, and olivine. May also contain amygdules filled with dolomite or calcite. The dike in the North Hartland Dam spillway contains mantle xenoliths of lherzolite, dunite, harzburgite, and clinopyroxenite (McHone and McHone. 2012). Generally, the dikes intrude parallel to joint sets and are unfoliated, but may be blocky jointed. Shown as polygonal map units or with strike and dip symbols: the thickness on the map is exaggerated to show location. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Kd - Mafic dikes (Cretaceous)
Dark-gray to black, locally rusty weathering, very fine grained, locally porphyritic lamprophyre, camptonite, or diabase dikes. Forty-six dikes are shown by point symbols, and range from centimeters (cm) up to 2.0 meters (m) thick. The dikes may contain phenocrysts of biotite, amphibole, pyroxene, and olivine and may also contain amygdules filled with dolomite or calcite. Generally, the dikes intrude parallel to steeply dipping joint sets and show variable orientations with a calculated principal trend of 63 degrees (°) ±5°. The dikes are unfoliated but may exhibit blocky jointing. One 3-m-thick dike was traced discontinuously for over 8 kilometers (km) from just north of Whitewater Reservoir near South Cornish to near the west side of Green Mountain; the dike parallels or intrudes a brittle fault. Thickness of the dikes is exaggerated on the map to show location. Many dikes cut the syenite (Ks) at Mount Ascutney, so these undated dikes are younger than about 122 Ma. Description from source

map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kt - Trachyte dikes (Cretaceous)

Kt - Trachyte dikes (Cretaceous)
Aphanitic, gray to light-gray, tan-weathering trachyte dikes. Dikes are approximately 1 to 1.5 m thick and may contain quartz and feldspar phenocrysts. Two north-northeast trending dikes occur in West Windsor on the eastern ridge of Blood Hill. The dikes intrude parallel to vertical joint sets and are unfoliated, but may be blocky jointed. Shown with strike and dip symbols only. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Kt - Trachyte dikes (Cretaceous)
Gray to light-gray, tan-weathering, very fine grained trachytic dikes. The dikes range in thickness from 0.7 to 1.5 m, are unfoliated, and may exhibit blocky jointing. Three dikes occur on the west side of Mount Ascutney and intrude the syenite (Ks), the hornfels (Kch), and the metamorphosed mafic volcanic rocks in the Waits River Formation (DSwa and DSwhg). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kfd - Spherulitic felsic dikes (Cretaceous)

Tan to light-gray, dark-gray to rusty weathering, very fine grained, discontinuously laminated, spherulitic felsic dikes. Flow laminations are 1 to 2 millimeters (mm) thick and are parallel to the walls of the dikes. Spherulites are 1 to 2 mm in diameter and are composed of radial, microlitic feldspathic material. The rock consists of 80 to 90 percent spherulites, 10 to 15 percent quartz, and accessory carbonate and sulfides. The rock crops out in an approximately 10-m-wide zone of en échelon dikes (20 to 40 cm thick) at an exposure in Mill Brook that is 1.1 km west of the junction of Interstate 91 and Route 131. The dikes are parallel to an east-west-striking and steeply north dipping joint set (strike 257°, dip 70°) and are shown on the map by a single brown strike-and-dip symbol. Balk and Krieger (1936) describe other felsic dikes with similar divitrification features in the vicinity of Mount Ascutney. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kch - Hornfels, inner metamorphic zone (Cretaceous)

Dark- and light-colored, foliated albite epidote to pyroxene hornfels. The hornfels is subdivided into outer (Kh) and inner (Kch) contact metamorphic zones based on a textural change from black to dark-gray, foliated, flinty hornfels (±biotite) (Kh) to a more indurated, variably light- and dark-colored, layered cordierite hornfels with only relict foliation (Kch); colors include (1) black to dark-gray, (2) purple to purplish-gray, (3) light-gray to bluish-green, and (4) light-pink. The outer contact between the hornfels (Kh) and the rocks of the Waits River Formation is transitional; the contact shown on the map is where the phyllitic and schistose character of the country rock loses its fissility and becomes flinty, but where the protolith is still recognizable. The hornfels becomes progressively indurated towards the intrusion. On the western side of the Ascutney Mountain stock, two rock units (DSwg and DSwa) in the Waits River Formation are locally mapped to the contact with the syenite (Ks) due to their coarse texture and recognizable older metamorphic minerals including coarse hornblende and garnet. The major contact metamorphic phases in the inner zone (Kch) are cordierite, spinel (pleonaste), biotite, garnet, corundum, and epidote (Daly, 1903) with minor andalusite (Nielson, 1973) and fibrolitic sillimanite (Schneiderman, 1989). Calcareous rocks contain diopside and wollastonite, and locally they contain grossularite and scapolite (Nielson, 1973). The Paleozoic foliation is generally preserved in the hornfels up to approximately 30 m from the intrusion, within which is a zone where the hornfels is locally brecciated and cut by syenitic and aplitic dikes. The main contact with the syenite is sharp and subvertical to steeply dipping inward towards the core of the pluton. Daly (1903), Nielson (1973), and Schneiderman (1989) describe the hornfels in detail. Schneiderman (1989, 1991) calculated a pressure of emplacement of the igneous complex at about 1.5 to 2 kilobars and a temperature of emplacement between 890 to 1000 degrees Celsius (°C); conditions equivalent to a depth between 6 and 15 km. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kh - Hornfels, outer metamorphic zone (Cretaceous)

Dark- and light-colored, foliated albite epidote to pyroxene hornfels. The hornfels is subdivided into outer (Kh) and inner (Kch) contact metamorphic zones based on a textural change from black to dark-gray, foliated, flinty hornfels (±biotite) (Kh) to a more indurated, variably light- and dark-colored, layered cordierite hornfels with only relict foliation (Kch); colors include (1) black to dark-gray, (2) purple to purplish-gray, (3) light-gray to bluish-green, and (4) light-pink. The outer contact between the hornfels (Kh) and the rocks of the Waits River Formation is transitional; the contact shown on the map is where the phyllitic and schistose character of the country rock loses its fissility and becomes flinty, but where the protolith is still recognizable. The hornfels becomes progressively indurated towards the intrusion. On the western side of the Ascutney Mountain stock, two rock units (DSwg and DSwa) in the Waits River Formation are locally mapped to the contact with the syenite (Ks) due to their coarse texture and recognizable older metamorphic minerals including coarse hornblende and garnet. The major contact metamorphic phases in the inner zone (Kch) are cordierite, spinel (pleonaste), biotite, garnet, corundum, and epidote (Daly, 1903) with minor andalusite (Nielson, 1973) and fibrolitic sillimanite (Schneiderman, 1989). Calcareous rocks contain diopside and wollastonite, and locally they contain grossularite and scapolite (Nielson, 1973). The Paleozoic foliation is generally preserved in the hornfels up to approximately 30 m from the intrusion, within which is a zone where the hornfels is locally brecciated and cut by syenitic and aplitic dikes. The main contact with the syenite is sharp and subvertical to steeply dipping inward towards the core of the pluton. Daly (1903), Nielson (1973), and Schneiderman (1989) describe the hornfels in detail. Schneiderman (1989, 1991) calculated a pressure of emplacement of the igneous complex at about 1.5 to 2 kilobars and a temperature of emplacement between 890 to 1000 degrees Celsius (°C); conditions equivalent to a depth between 6 and 15 km. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kspb - Syenite, plutonic breccia (Early Cretaceous)

Light-gray, dark-green to chalky white weathering to very light gray to rusty weathering, coarse-grained, locally porphyritic, biotite-hornblende-perthite syenite. Contains accessory magnetite and minor clinopyroxene (augite), fayalite, and quartz (Schneiderman, 1991). Perthite is locally sericitized. The rock contains accessory apatite, zircon, titanite, monazite, and magnetite (Schneiderman, 1991) and commonly contains xenoliths. Near the contact with the country rock (within ~400 m or less), large meter scale and smaller xenoliths of hornfels are common. At distances greater than 400 m from the contact, hornfels xenoliths are rare or absent. The most common xenoliths are black to dark-grayish-purple, porphyritic volcanic rock with white, coarse-grained, euhedral to subhedral feldspar crystals in an aphanitic fine-grained dark matrix. Originally called “basic segregations” by Daly (1903), they were later interpreted as xenoliths (Chapman and Chapman, 1940; Foland and others, 1985; Schneiderman, 1991). The xenoliths are commonly softball sized or smaller and angular to subrounded in shape. Areas with a very high density of xenoliths (up to 70 or 80 percent of the rock) are mapped separately as plutonic breccia (Kspb), most notably at Cascade Falls. Large (kilometer-scale) screens of volcanic rock are mapped separately within the syenite on the west side of Mount Ascutney. Dikes of syenite that contain xenoliths of gneiss of the Mount Holly Complex (for example, station MA-1536 in the GIS database) intrude the gabbro and diorite of the Little Ascutney stock (Kgd). Syenite occurs as the main stock of Mount Ascutney and occurs as dikes (generally less than 1 m thick) in the country rock surrounding the pluton. Outcrop-scale dikes are shown by strike and dip symbols. The unit hosts three abandoned quarries (Mower, Enwrighte, and Norcross) (Dale, 1909, 1923; Morrill and Chaffee, 1964). The quarried stone was called the “Windsor granite” or “Ascutney green” (Dale, 1909, 1923). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kv - Trachyte to rhyolite and volcanic breccia (Early Cretaceous)

Gray to purple, fine-grained, undifferentiated trachyte to rhyolite tuff and volcanic breccia containing fragments of volcanic rocks having trachytic flow structure and layering. The unit is interpreted as volcanic rocks of the edifice. Three samples from Kv (fig. 2) are chemically similar to the syenite (Ks) and biotite-granite plutons (Kg). Two analyses of “basic segregation” xenoliths from within the biotite granite (Kg) plot as trachyandesite on the total-alkali versus silica (TAS) diagram (fig. 2A) from data in Daly (1903, p. 84). Foland and others (1985) described the xenoliths as basaltic. The more mafic rocks are mapped separately within the Kspb unit, but their chemistry was not independently confirmed in this study. The Kv unit is well-exposed south and west of the Mount Ascutney summit on the hiking trails (Weathersfield Trail and Hang Glider Trail, names not on map) and upstream of Crystal Cascade Falls. Schneiderman (1989) and Chapman and Chapman (1940) describe the volcanic units at Mount Ascutney in greater detail. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Kgd - Gabbro and diorite (Early Cretaceous)

Undifferentiated, coarse grained, dark-green hornblende-biotite gabbro and lighter colored, crosscutting, medium- to coarse-grained, biotite-hornblende diorite. In places, the biotite-hornblende diorite may be porphyritic. The unit is intruded by bodies of mapped syenite (Ks) and dikes of aplite (Ka). Foland and Faul (1977) and Foland and others (1985) dated the gabbro-diorite complex at 125.5 to 122.2 Ma by biotite K-Ar ages and by whole-rock Rb/Sr ages. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Msz - Silicified zone (Mesozoic)

Very dark gray to white, brecciated and recrystallized, vein quartz and brecciated quartz-laminated phyllite of the Littleton Formation (Dl). Contains accessory calcite, opaques, chlorite, and muscovite. Occurs as an approximately 5- to 15-m thick, sub-vertical zone in Plainfield west of Willard Ledge, between the two splays of the Ammonoosuc fault. The orientation of the silicified zone is consistent with development in the R-shear plane during right-lateral (dextral) displacement of the fault. Thickness of the zone is exaggerated to show its location. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

KDq - Quartz veins (Cretaceous and Devonian)

KDq - Quartz veins (Cretaceous and Devonian)
White quartz veins; may locally contain small amounts of muscovite, chlorite, graphite, sulfides, and carbonate minerals. Shown as polygonal map units or with strike and dip symbols. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

KDq - Quartz veins (Cretaceous to Devonian)
White- to gray-weathering quartz veins ranging in size from 0.1 to 3 m. The rock may locally contain small amounts of muscovite, chlorite, graphite, sulfides, and carbonate minerals. The unit is shown as a single polygonal map unit, or shown with strike-and-dip or diamond-point symbols; thickness of the unit is exaggerated on the map to show location. The 10-m-thick vein exposed near the southern border of the map (east of Claremont) is mapped as a Mesozoic silicified zone related to brittle faulting. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dg - Granite (Devonian)

Massive to moderately well foliated, ±garnet±microcline-muscovite-biotite-quartz-plagioclase granite to trondhjemite dikes and sills. The dikes cut an early bed-parallel foliation (S1) in the Silurian to Devonian rocks and pre-date the development of the S2 foliation. The unit may be shown on the map by a strike-and-dip symbol only. The stock at Bald Mountain intrudes the Littleton Formation and yields a uranium-lead (U-Pb) sensitive high-resolution ion microprobe (SHRIMP) zircon age of 395±5 Ma (Walsh and others, 2014). The Bald Mountain granite was previously mapped as either “granodiorite gneiss and related rocks” (“Db” of Thompson and others, 1990) or as volcanic rocks in the Littleton Formation (“Dlv” of Lyons and others, 1997). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dp - Pegmatite (Devonian)

White- to pink-weathering, massive, ±garnet-tourmaline-biotite-muscovite-quartz-K-feldspar pegmatite. Pegmatite layers are mainly concordant with the dominant foliation and layering, but locally they crosscut the rocks they intrude. Mapped pegmatite is restricted to the southeastern part of the map where the pegmatite is deformed by the D2 deformation fabric in these rocks. The unit is shown as polygonal map units, or shown with strike-and-dip or reddish-pink diamond symbols; thickness of the unit may be exaggerated on the map to show location. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dgm - Gile Mountain Formation, Meetinghouse Slate Member (Lower Devonian)

Dgm - Gile Mountain Formation, Meetinghouse Slate Member (Lower Devonian)
Dark-gray and silvery gray, lustrous, carbonaceous, plagioclase-quartz-chlorite-muscovite slate and phyllite rhythmically interbedded with lesser micaceous plagioclase-quartz granofels and micaceous quartzite similar to Dgf. Quartzite and granofels beds generally range in thickness from 1 to 5 centimeters (cm), and rarely exceed 10 cm thick. A 10-cm-thick bed of small-pebble quartz-rich conglomerate was observed at one place in Plainfield on Short Knoll. The unit is well exposed at the North Hartland Dam spillway. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgm - Gile Mountain Formation, Meetinghouse Slate Member (Lower Devonian)
Silvery gray to gray, fine- to medium-grained, ±calcite-chlorite-biotite-muscovite-quartz phyllite and schist with beds of biotite-muscovite quartzite. All major minerals form the dominant foliation with syn- to late-fabric-forming biotite porphyroblasts. Accessory minerals include epidote, apatite, rutile, ilmenite, and magnetite. Quartzite layers vary from mm-scale to 20 cm thick. The unit becomes “pinstriped” near the Monroe thrust fault due to mylonitization. The unit is exposed on the east side of the Meriden antiform. The lower contact is gradational with Dgq, and the upper contact is the Monroe thrust fault. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSm - Melange (Lower Devonian and Silurian?)

Dark-gray to black, rusty weathering, sulfidic, polymict conglomerate to breccia with a rusty weathering, dark-gray to black, sulfidic graphite-chlorite-biotite-muscovite-quartz schist matrix. The unit contains clasts of gray, black. and tan quartzite, pebbly quartzite, vein quartz, black schist, metavolcanic rocks, and rare granitoid suggesting the rock is derived from the pre-Silurian rocks in the Bronson Hill arc. Some clasts have a metamorphic fabric which implies a pre-deformed source.

The unit also contains gray, calcareous graphite-chlorite-calcite-muscovite-biotite- quartz granofels with small vugs at one place at French's Ledges (labeled "cal" on map); this rock resembles the Fitch Formation unit Sfgr. The matrix may be reworked Partridge Formation. The belt of rocks is in the stratigraphic position of the Partridge Formation or Clough Quartzite on the east side of the Meriden antiform, between the metafelsite of the Ammonoosuc Volcanics (Oaf) to the east and the Gile Mountain Formation occurring to the west. We interpret this rock as a melange, either tectonic or sedimentary (Raymond, 1984), and suggest that it may possibly be correlative with polymict conglomerate seen at Chestnut Hill in the Springfield quadrangle (Walsh and others, 1996a,b; Armstrong and others, 1997; Thompson and others, 2012). At Chestnut Hill, the melange contains clasts of the Clough Quartzite indicating that its formation postdates deposition of the Clough (Thompson and others, 2012). The melange is spatially related to the Monroe thrust, supporting a tectonic origin for this belt of rock (Thompson and others, 2012). The melange is exposed on either side of Route 120 near the junction of Whitaker Road and south of the junction with Underhill Road. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dl - Littleton Formation, schist member (Lower Devonian)

Dl - Littleton Formation, gray quartz-laminated phyllite member (Lower Devonian)
Gray quartz-laminated phyllite member-Dark-gray to light silvery gray, lustrous, locally thinly laminated, carbonaceous chlorite±biotite- plagioclase-quartz-muscovite schist and phyllite with interbedded gray micaceous or feldspathic quartzite. Typical exposures occur at Willard Ledge and on Prospect Hill in the Prospect Hill belt. The unit of Dl shown in the southeastern corner of the map in Corbin Park, east of the Northey Hill fault, was extrapolated from Lyons (1955) and from ongoing mapping in the adjacent Claremont North quadrangle. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dl - Littleton Formation, schist member (Lower Devonian)
Silvery gray to dark-gray, fine- to medium-grained, biotite-chlorite-muscovite-quartz schist, minor carbonaceous muscovite-quartz schist, and interbedded muscovite schist and micaceous quartzite (metaturbidite). Locally, the unit exhibits rusty weathering, and in such places, it is extremely difficult to distinguish this unit from the Partridge Formation. The unit contains garnet and characteristic large staurolite (up to 1.5 cm wide x 10 cm long) at higher metamorphic grades. Locally, garnet is completely pseudomorphed by chlorite. Staurolite typically has retrograde muscovite (±chlorite rims) and locally exhibits complete replacement by muscovite±chlorite at lower grades and partial to complete replacement by muscovite and sillimanite (fibrolite) at higher grade in the eastern edge of the map along Brighton Road. The unit is in contact with the Clough Quartzite or the Partridge Formation along much of the Northey Hill shear zone and unconformably overlies the Clough Quartzite and Fitch Formation west of Green Mountain. The unit is in gradational contact with Dlq and is locally conformable with the Fitch Formation in the eastern part of the map. Typical exposures occur along the power line east of Bald Mountain. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dlcg - Littleton Formation, metaconglomerate member (Lower Devonian)

Gray to very light gray, white chalky weathering, fine- to coarse-grained, metamorphosed quartz-pebble conglomerate and polymict conglomerate. Conglomerate varies from clast-supported conglomeratic layers (up to 30 cm thick) to isolated, matrix-supported pebbles. The unit may contain felsic volcanic clasts or volcaniclastic rock. Southwest of Bald Mountain, the unit occurs as lenses within the Dl member less than 200 m above the contact between Dl and the metaconglomerate member (Scq) of the Clough Quartzite. Thickness of the unit varies from 1 to 5 m and is exaggerated on the map to show its location. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dlc - Littleton Formation, coticule and ironstone member (Lower Devonian)

Dark-gray to light silvery gray, lustrous, locally thinly laminated, carbonaceous chlorile±biotite-plagioclase-quartz-muscovite schist and phyllite, and thin quartzite with distinctive, thin (l- to 20-cm-thick) layers of pink to yellowish-pink coticule, garnetiferous quartzite, and dark-gray to black ironstone; contains chlorite pseudomorphs after retrograded biotite and garnet. The unit crops out at the base of the Littleton Formation in the Prospect Hill belt. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dlq - Littleton Formation, interbedded quartzite and schist member (Lower Devonian)

Silvery gray to dark-gray, micaceous quartzite; interbedded micaceous quartzite and biotite-muscovite-quartz schist; and carbonaceous schist. Quartzite layers are distinctly “sandy” or rough to the touch. The unit contains characteristic garnet and large cm-scale staurolite at higher metamorphic grades. Locally, garnet is completely pseudomorphed by chlorite. Staurolite typically has retrograde muscovite (±chlorite rims) and locally exhibits complete replacement by muscovite±chlorite at lower grades and partial replacement by muscovite and sillimanite at higher grade. Locally, the unit is also magnetite-rich near the contact with the Fitch Formation. The lower contact is unconformable with the Clough Quartzite. The contact with the Fitch Formation is locally conformable but predominantly unconformable. The contact between Dl and Dlq is gradational and interpreted as a facies change; Dlq is typically the lowest unit in the Littleton Formation in the eastern part of the map but in places, it is interfingered with Dl. Typical exposures occur along the power line southwest of Chapin Pond and along Cat Hole Road north of Green Mountain. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dgq - Gile Mountain Formation, feldspathic quartzite, granofels, and metapelite member (Lower Devonian)

Dgq - Gile Mountain Formation, feldspathic quartzite, granofels, and metapelite member (Lower Devonian)
Light-gray, tan-weathering, massive, micaceous, feldspathic quartzite and micaceous plagioclase-quartz granofels interbedded with lesser dark-gray carbonaceous chlorite-biotite-muscovite-plagioclase-quartz slate, phyllite, or schist. Locally, the unit is a slightly calcareous rock that contains round-weathering pits as much as a few cm across. Quartzite and granofels comprise approximately 50 to 90 percent of the unit in beds that generally range in thickness from 2 to 100 cm. In the core of the Meriden antilorm the unit consists largely of quartzite, locally with 10 percent or less of metapelite. The unit is well exposed in Cornish and Plainfield on Fernald Hill, Yetsevitch Hill, Stevens Hill, and on the lower western slopes of Home Hill. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgq - Gile Mountain Formation, feldspathic quartzite, granofels, and metapelite member (Lower Devonian)
Light-gray, tan-weathering, massive, micaceous, feldspathic quartzite and micaceous plagioclase-quartz granofels interbedded with lesser dark-gray carbonaceous chlorite-biotitemuscovite-plagioclase-quartz slate, phyllite, or schist. Locally, where the unit is slightly calcareous, it contains round-weathering pits as much as a few cm across. The unit contains approximately 50 to 90 percent quartzite and granofels in beds that generally range in thickness from 2 to 100 cm. The core of the Meriden antiform (Dgq) consists mainly of quartzite, and locally consists of 10 percent or less of metapelite. Layering becomes tectonically “pinstriped” near the Monroe thrust fault. The lower contact is gradational with the Waits River Formation. The upper contact is either (1) a facies change, where it

is in contact with upper members of the Gile Mountain Formation; or (2) tectonic in nature, where it is in contact with the Ammonoosuc Volcanics and Partridge Formation. The unit is well exposed in Cornish on Kenyon Hill, Parsonage Hill, and Spaulding Hill. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dgqs - Gile Mountain Formation, gray quartzite and metapelite member (Lower Devonian)

Dgqs - Gile Mountain Formation, gray quartzite and metapelite member (Lower Devonian)
Dark- to light-gray, lustrous, carbonaceous, chlorite±garnet±biotite-plagioclase-quartz-muscovite schist and phyllite, locally interbedded with thin gray quartzite, tan to gray feldspathic quartzite, and gritty micaceous plagioclase-quartz granofels. The unit is locally sulfidic and is similar to the phyllite and schist member (DSws) of the Waits River Formation, but generally has more quartzite beds. Typical exposures occur in Hartland on Kent Hill. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgqs - Gile Mountain Formation, gray quartzite and metapelite member (Lower Devonian)
Dark- to light-gray, locally sulfidic, lustrous, carbonaceous chlorite±garnet±biotite-plagioclase-quartz-muscovite schist and phyllite, locally interbedded with thin gray quartzite, tan to gray feldspathic quartzite, and gritty micaceous plagioclase-quartz granofels. Quartzite is generally less than 50 percent of the unit. The unit is similar to the phyllite and schist member (DSws) of the Waits River Formation, but generally has more quartzite beds, and is also similar to the metapelite member of the Gile Mountain Formation (Dgq), but has fewer quartzite beds. Typical exposures occur in Windsor on Horseback Ridge. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dgqc - Gile Mountain Formation, quartzite, conglomerate, and metapelite member (Lower Devonian)

Interbedded, tan-weathering, gray micaceous quartzite; dark-gray, fine-grained, polymict conglomerate to breccia; and silvery gray to dark-gray, locally rusty weathering phyllite to schist. The conglomerate occurs in beds as much as 4 m thick. Clasts occur in a gray metapelite matrix and consist of Quartz veins, chips of black metapelite, gray quartzite, sulfidic metapelite, and possible metafelsite and green schist. The conglomerate is present In the North Hartland quadrangle in the Meriden antiform. and is well exposed on Penniman Hill. East of Whitaker Road the rock contains clasts of white and gray calcite marble, and there it is mapped as unit Dgqcm. A white quartzite to quartz-pebble conglomerate mapped as Dgqq was observed at a single outcrop on the west side of Penniman Hill at an elevation of 1.040 feet. Dgqq resembles the Clough Quartzite (unit Scq). The conglomerate may represent Devonian flysch deposits in front of the advancing Acadian thrust sheets such as the Monroe thrust sheet. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgg - Gile Mountain Formation, greenstone member (Lower Devonian)

Green to greenish-black, fine- to medium-grained, massive to schistose, ±carbonate-epidote-actinolite-plagioclase-chlorite greenstone and silvery gray-green ankerite-plagioclase-chlorite-quartz schist. The unit is interpreted as metamorphosed volcanic and volcaniclastic rocks. Small discontinuous exposures are present southwest of Cornish Flat with a more extensive belt exposed on the western limb of the Meriden antiform. The unit is poorly exposed in an unnamed stream on the north side of Dingleton Hill. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Dgqq - Gile Mountain Formation, quartzite, conglomerate, and metapelite member, white quartzite to quartz-pebble conglomerate (Lower Devonian)

Interbedded, tan-weathering, gray micaceous quartzite; dark-gray, fine-grained, polymict conglomerate to breccia; and silvery gray to dark-gray, locally rusty weathering phyllite to schist. The conglomerate occurs in beds as much as 4 m thick. Clasts occur in a gray metapelite matrix and consist of Quartz veins, chips of black metapelite, gray quartzite, sulfidic metapelite, and possible metafelsite and green schist. The conglomerate is present In the North Hartland quadrangle in the Meriden antiform. and is well exposed on Penniman Hill. East of Whitaker Road the rock contains clasts of white and gray calcite marble, and there it is mapped as unit Dgqcm. A white quartzite to quartz-pebble conglomerate mapped as Dgqq was observed at a single outcrop on the west side of Penniman Hill at an elevation of 1.040 feet. Dgqq resembles the Clough Quartzite (unit Scq). The conglomerate may represent Devonian flysch deposits in front of the advancing Acadian thrust sheets such as the Monroe thrust sheet. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgqcm - Gile Mountain Formation, quartzite, conglomerate, and metapelite member, white and gray calcite marble (Lower Devonian)

Interbedded, tan-weathering, gray micaceous quartzite; dark-gray, fine-grained, polymict conglomerate to breccia; and silvery gray to dark-gray, locally rusty weathering phyllite to schist. The conglomerate occurs in beds as much as 4 m thick. Clasts occur in a gray metapelite matrix and consist of Quartz veins, chips of black metapelite, gray quartzite, sulfidic metapelite, and possible metafelsite and green schist. The conglomerate is present In the North Hartland quadrangle in the Meriden antiform. and is well exposed on Penniman Hill. East of Whitaker Road the rock contains clasts of white and gray calcite marble, and there it is mapped as unit Dgqcm. A white quartzite to quartz-pebble conglomerate mapped as Dgqq was observed at a single outcrop on the west side of Penniman Hill at an elevation of 1.040 feet. Dgqq resembles the Clough Quartzite (unit Scq). The conglomerate may represent Devonian flysch deposits in front of the advancing Acadian thrust sheets such as the Monroe thrust sheet. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgh - Gile Mountain Formation, hornblende fascicle schist member (Lower Devonian)

Silvery gray, medium- to coarse-grained, calcite-hornblende-quartz-biotite schist with conspicuous hornblende fascicles; contains accessory muscovite and chlorite. Crops out on Blake Hill in the northwestern corner of the map. The unit is interpreted as a volcaniclastic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgf - Gile Mountain Formation, felsic gneiss and quartzose granofels member (Lower Devonian)

Light-gray, biotite-quartz-plagioclase gneiss, and feldspathic biotite quartzite and granofels with accessory hornblende and garnet. The unit resembles DSwf and crops out on Blake Hill in the northwestern corner of the map. The unit is interpreted as a mixed volcaniclastic and sedimentary rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Dgab - Gile Mountain Formation, ankeritic biotite schist member (Lower Devonian)

Dark-gray, rusty spotted, ankerite-quartz-biotite schist with accessory plagioclase, epidote, chlorite, and garnet. Observed within Dgqs at one place in the headwaters of Fulling Brook in Hartland at an approximate elevation of 1,100 feet. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSfm - Fitch Formation, marble member (Lower Devonian and upper Silurian)

Sfm - Fitch Formation, marble member (Lower Devonian and upper Silurian)
Light-gray to white, gray to orange-tan weathering, opaque-quartz-muscovite-calcite marble and sphene-epidote-quartz-garnet-muscovite-biotite-calcite marble. Garnetiferous marble occurs in layers above the contact with the calc-silicate granofels member (Sfgr). Garnet porphyroblasts are poikilitic and up to 1 cm across. Contains interbedded layers of gray calc-silicate granofels at the contact with Slgr at the railroad cut in Hartford, west of Johnston Island. The unit is exposed at the railroad cut on the east side of Prospect Hill in Hartford, Vt., and on the east side of Read Hill; crops out at the top of the Fitch Formation. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSfgr - Fitch Formation, calc-silicate granofels member (Lower Devonian and upper Silurian)

Sfgr - Fitch Formation, calc-silicate granofels member (Lower Devonian and upper Silurian)
Gray to bluish-gray or gray-green, dark-gray to light-gray weathering, massive, calcite-biotite-chlorite-muscovite-plagioclase-quartz granofels with distinctive small (as little as a few centimeters) calcite-filled vugs and weathered pits. Contains as much as a few percent sphene, apatite, epidote, and opaques. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSfs - Fitch Formation, laminated schist member (Lower Devonian and upper Silurian)

Sfs - Fitch Formation, laminated schist member (Lower Devonian and upper Silurian)
Silvery gray green, banded to laminated, magnetite-chlorite-biotite-epidote-quartz-plagioclase-muscovite schist and garnet-biotite-quartz-muscovite schist. Contains thin (centimeter-scale) layers and boudins of magnetite-garnet-quartz coticule. The member is interlayered with the greenstone member (Sfg) along its lower contact. The unit crops out on the eastern side of Read Hill above the greenstone member (Sfg) and below the marble member (Sfm) or Littleton Formation (Dl). Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSfg - Fitch Formation, greenstone member (Lower Devonian and upper Silurian)

Sfg - Fitch Formation, greenstone member (Lower Devonian and upper Silurian)
Massive to layered, green to gray-green, fine-grained, ±imlenite±apatite±calcite±actinolite±biotite-quartz-chlorite-epidote-hornblende-plagioclase amphibolite or greenstone. The unit is exposed in Plainfield from Mill Village to southwest of Bartlett Four Corners, and typical exposures occur in Blow-Me-Down Brook upstream of Mill Village where it contains deformed pillows. The unit occurs above the Clough Quartzite at the base of the Fitch Formation. The unit is interpreted as mafic volcanic and

volcaniclastic rock; perhaps correlative to potential feeder dikes of the Cornerford Intrusive Complex (Scd). Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Sfg - Greenstone member of Fitch Formation (Lower Devonian and upper Silurian)
Green to gray-green, fine-grained, massive to layered, ±ilmenite±apatite±calcite±actinolite±biotite-quartz-chlorite-epidote-hornblende-plagioclase amphibolite or greenstone and laminated chlorite schist. The unit exposed on the north slopes of Dingleton Hill where it extends into the adjacent North Hartland quadrangle (Walsh, 2016). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSf - Fitch Formation, gray granofels and schist member (Lower Devonian and upper Silurian)

Sf - Fitch Formation, gray granofels and schist member (Lower Devonian and upper Silurian)
Gray to dark-greenish-gray, medium-grained, ±magnetite-actinolite/tremolite-epidote-muscovite-biotite-carbonate-plagioclase-quartz granofels and schist. Locally, the rock contains distinctive, irregular dissolution cracks and holes along bedding (informally called “ant rock”). The unit contains (1) calc-silicate pods consisting of garnet, quartz, actinolite, and diopside; (2) variably rusty to bronze-weathering, medium-grained, carbonate-biotite-quartz schist with carbonate pods and layers that are 2 to 10 cm thick; (3) gray to light-gray, medium-grained, biotite-chlorite-garnet-muscovite-quartz schist; and (4) micaceous quartzite with distinctive high-relief weathering quartz-rich knots, pods, layers or pebbles; pods consists predominantly of quartz but also contain garnet, magnetite, biotite, and muscovite. Disseminated magnetite is common in all rock types. Locally, mm- to cm-scale magnetite layers are present near the contact with the Littleton Formation and Clough Quartzite. The unit is best exposed between Ram Brook and Brighton Road and just west of the Cornish Turnpike along the Cornish-Claremont town line. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DScd - Metadiabase dike (Lower Devonian and upper Silurian)

Scd - Lake Memphremagog Intrusive Suite, metadiabase dike (Silurian)
Massive, medium-grained, very dark green to black and white, calcite-epidote±garnet-chlorite-biotite-hornblende-plagioclase amphibolite to diorite granofels with white plagioclase phenocrysts up to 1 cm long. The dikes contain leucocratic black and white segregations of hornblende-plagioclase pegmatitic diorite with intergrown phenocrysts up to 2 cm across, postdate compositional layering within the Ammonoosuc Volcanics, and measure as much as several meters thick. Shown as map units or as strike and dip symbols The map units consist of swarms of dikes In the host Ammonoosuc Volcanics. The unit is correlated with the Cornerford Intrusive Complex dated at 419±1 Ma (Rankin and others. 2007). The unit is interpreted as feeder dikes to the Fitch Formation greenstone member (Sfg). Typical exposures occur on Black Hill, Potato Hill, and the west side of Pinnacle Hill. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Scd - Lake Memphremagog Intrusive Suite, metadiabase dike (Silurian)
Very dark green to black and white, medium-grained, massive, ±garnet-calcite-epidote-chlorite-biotitehornblende- plagioclase amphibolite. At one location, the unit was found exposed on a jeep trail on the northwest side of Green Mountain within the Clough Quartzite, but contacts with surrounding quartzite are not exposed at the location. Alternatively, the amphibolite could be a volcanic layer and not a dike. The unit is considered an age-equivalent of the mafic dikes dated at 419±1 Ma by Rankin and others (2007). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwl - Waits River Formation, limestone and schist member (Lower Devonian and upper Silurian)

DSwl - Waits River Formation, limestone and schist member (Lower Devonian and upper Silurian)
Dark- to light-gray, locally sulfidic and rusty-weathering, lustrous, carbonaceous chlorite±garnet±biotite-plagioclase-quartz-muscovite schist and phyllite with characteristic interbedded dark-blue-gray, dark-brown punky weathering, impure siliceous limestone or marble, quartz-rich calcareous schist, and gray calcareous to non-calcareous quartzite. The phyllite contains less than 10 percent chlorite and plagioclase, and accessory biotite and garnet porphyroblasts in the garnet zone and rare biotite porphyroblasts in the biotite zone. The limestones contain trace to 5 percent muscovite, 20 to 40 percent quartz, and 60 to 80 percent calcite with accessory plagioclase, pyrite, opaques, graphite, tourmaline, and apatite Limestone beds generally measure 0.1 to 3.0 m thick; bedding in the metapelite is generally not visible. The unit is well exposed on Interstate 91 and in Lulls Brook south of the village of Hartland. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwl - Waits River Formation, limestone and schist member (Lower Devonian and Silurian)
Dark- to light-gray, locally sulfidic and rusty weathering, lustrous, carbonaceous chlorite±garnet±biotite-plagioclase-quartz-muscovite schist and phyllite with characteristic interbedded dark-blue-gray, dark-brown punky weathering, impure siliceous limestone or marble, quartz-rich calcareous schist, and gray calcareous to non-calcareous quartzite. The phyllite contains less than 10 percent chlorite and plagioclase, accessory biotite and garnet porphyroblasts in the garnet zone, and rare biotite porphyroblasts in the biotite zone. The limestones contain trace to 5 percent muscovite, 20 to 40 percent quartz, and 60 to 80 percent calcite with accessory plagioclase, pyrite, opaques (including graphite), tourmaline, and apatite. The unit is distinguished from the adjacent metasedimentary units by the abundance of brown-weathered limestone and rusty calcite-bearing schist. Beds of limestone range in thickness from 1 cm to 1.5 m and may constitute 10 to 90 percent of an exposure; bedding in the metapelite is generally not visible. Contacts with adjacent units are gradational to sharp and are mapped where limestone beds decrease in abundance and thickness. Contacts with DSws are interpreted as facies changes and may not necessarily imply stratigraphic order. The unit is well-exposed along Interstate 91. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSws - Waits River Formation, gray phyllite and schist member (Lower Devonian and upper Silurian)

DSws - Waits River Formation, gray phyllite and schist member (Lower Devonian and upper Silurian)
Dark- to light-gray, lustrous, carbonaceous chlorite±garnet±biotite-plagioclase-quartz-muscovite schist and phyllite, locally interbedded with thin gray quartzite, tan to gray feldspathic quartzite, and gritty micaceous plagioclase-quartz granofels. The unit contains trace limestone and is similar to the quartzite and metapelite member (Dgqs) of the Gile Mountain Formation, but generally has fewer quartzite beds. Typical exposures occur in Hartland in the valley of Densmore Brook. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSws - Waits River Formation, gray phyllite and schist member (Lower Devonian and Silurian)
Dark- to light-gray, fine-grained, lustrous, carbonaceous chlorite-muscovite-plagioclase-quartz schist and phyllite. In places, the unit contains interbedded thin gray quartzite, tan to gray feldspathic quartzite, and gritty plagioclase-quartz granofels that is similar to Dgq; mapped separately in one location as DSwq (where thick enough) in the south-central part of the map, east of Gird Lot Road in Weathersfield. Beds range in thickness from 3 to 10 cm. Locally, the unit contains trace amounts of very thin (1 to 2 cm) brown-weathering limestone beds. The schist contains biotite and garnet in the western part of the map. The unit is similar to Dgqs, but generally has fewer quartzite layers.

Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwq - Waits River Formation, gray phyllite and schist member, quartzite and granofels (Lower Devonian and upper Silurian)

DSwq - Waits River Formation, quartzite member (Lower Devonian and upper Silurian)
Gray micaceous quartzite, tan to gray feldspathic quartzite, and dark-gray to blue-gray, carbonaceous muscovite-chlorite-plagioclase quartz-rich schist and micaceous quartzite. The unit resembles quartzites of Dgq. The unit crops out in the Connecticut River at Sumner Falls. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwq - Waits River Formation, gray phyllite and schist member, quartzite and granofels (Lower Devonian and Silurian)
Dark- to light-gray, fine-grained, lustrous, carbonaceous chlorite-muscovite-plagioclase-quartz schist and phyllite. In places, the unit contains interbedded thin gray quartzite, tan to gray feldspathic quartzite, and gritty plagioclase-quartz granofels that is similar to Dgq; mapped separately in one location as DSwq (where thick enough) in the south-central part of the map, east of Gird Lot Road in Weathersfield. Beds range in thickness from 3 to 10 cm. Locally, the unit contains trace amounts of very thin (1 to 2 cm) brown-weathering limestone beds. The schist contains biotite and garnet in the western part of the map. The unit is similar to Dgqs, but generally has fewer quartzite layers. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwv - Waits River Formation, laminated schist and granofels member (Lower Devonian and Silurian)

DSwv - Waits River Formation, laminated schist and granofels member (Lower Devonian and upper Silurian)
Heterogeneous, laminated to layered, green and white, in places rusty weathering, fine- to medium-grained, muscovite±biotite-chlorite-quartz-plagioclase schist; (2) silvery green, fine- to medium-grained muscovite±biotite-chlorite-quartz-plagioclase schist; (3) gray-green, medium-grained, muscovite±biotite-chlorite-quartz-plagioclase granofels; (4) greenstone; and (5) silvery gray, rusty weathering, carbonaceous calcite-plagioclase-quartz-chlorite-biotite-muscovite schist. The unit contains accessory calcite and ilmenite and is interpreted as a heterogeneous assemblage of volcaniclastic sediments and primary volcanic rocks. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwv - Waits River Formation, laminated schist and granofels member (Lower Devonian and Silurian)
Heterogeneous unit consisting of (1) laminated (mm-scale) to layered (cm-scale), green and white, in places rusty weathering, fine- to medium-grained, muscovite±biotite-chloritequartz- plagioclase schist; (2) silvery green, fine- to mediumgrained, muscovite±biotite-chlorite-quartz-plagioclase schist; (3) gray-green, medium-grained, muscovite±biotite-chlorite-quartz plagioclase granofels; (4) gray to light-gray, ±carbonate±garnetbiotite- chlorite-muscovite-quartz-plagioclase granofels in 5-cm- to 2-m-thick beds with coarse (1- to 8-mm-diameter) plagioclase and quartz porphyroclasts; (5) green, fine-grained, quartz-epidote chlorite- plagioclase schist or greenstone; and (6) silvery gray, rusty weathering, calcite-muscovite-chlorite-quartz-plagioclase schist. The unit contains accessory ilmenite porphyroblasts and porphyroclasts 1- to 5-mm long, and in places, is pitted where it contains accessory carbonate. The unit is interpreted as a heterogeneous assemblage of metamorphosed volcaniclastic and primary volcanic rocks. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwf - Waits River Formation, felsic gneiss and quartzose granofels member (Lower Devonian and Silurian)

DSwf - Waits River Formation, felsic gneiss and quartzose granofels member (Lower Devonian and upper Silurian)
Light-gray, biotite-quartz-plagioclase gneiss, and feldspathic biotite quartzite and granofels with accessory hornblende and garnet. The unit is interpreted as a volcaniclastic sedimentary and primary sedimentary rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwf - Waits River Formation, felsic gneiss and quartzose granofels member (Lower Devonian and Silurian)
Light-gray, tan-weathering, biotite-quartz-plagioclase gneiss and medium-gray, feldspathic, biotite quartzite and granofels interpreted as volcaniclastic rock interbedded with DSwhg. The unit is present in the northwest part of the map near Sheddsville. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwvp - Waits River Formation, porphyritic schist and granofels member (Lower Devonian and upper Silurian)

Gray-green to light-gray, medium-grained, actinolite-muscovite-quartz-plagioclase-chlorite-biotite schist with quartz and plagioclase phenocrysts up to 1 cm long: contains accessory calcite, ilmenite, apatite, and idocrase. The unit is interpreted as a primary volcanic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwg - Waits River Formation, large-garnet and hornblende garbenschiefer schist member (Lower Devonian and Silurian)

DSwgs - Waits River Formation, large garnet and hornblende garbenschiefer schist member (Lower Devonian and upper Silurian)
Silvery gray to light-gray, in places rusty weathering, calcite-epidote-chlorite-garnet-hornblende-plagioclase-quartz-biotite-muscovite schist with distinctive sprays of hornblende and large garnet porphyroblasts. The unit is interpreted as metamorphosed pelitic sediments with a volcaniclastic component. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwg - Waits River Formation, large-garnet and hornblende garbenschiefer schist member (Lower Devonian and Silurian)
Silvery gray to light-gray, in places rusty weathering, epidote-biotite-chlorite-muscovite-garnet-hornblende-quartz-plagioclase schist with distinctive 1- to 5-cm-long sprays of hornblende and 1- to 5-cm-diameter garnet porphyroblasts. The unit is interpreted as metamorphosed pelitic sedimentary rock with a volcaniclastic component of intermediate to mafic composition, and is interlayered with multiple units in the formation. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwhg - Waits River Formation, hornblende-plagioclase gneiss member (Lower Devonian and Silurian)

DSwhg - Waits River Formation, hornblende-plagioclase gneiss member (Lower Devonian and upper Silurian)
Medium-grained to very coarse grained, black and white to dark-green, calcite-epidote±garnet-chlorite-biotite-hornblende-plagioclase amphibolite gneiss with roughly equal percentages of hornblende and plagioclase; contains accessory calcite and ilmenite. The unit is interpreted as a mafic

volcanic flow or composite flow. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwhg - Waits River Formation, hornblende-plagioclase gneiss member (Lower Devonian and Silurian)
Dark-green, medium- to coarse-grained, ±garnet-epidote-chlorite-hornblende-plagioclase gneiss with roughly equal percentages of hornblende and plagioclase. The unit varies from a massive, weakly foliated, very coarse grained gneiss to a well-layered gneiss. Where massive, intergrowths of hornblende with matrix plagioclase are ubiquitous, forming a possible replacement of relict ophitic texture. Unit exposures north of Hunt Road in Windsor are the well-layered variety; the massive variety may, in part, be intrusive. Contacts with surrounding units are sharp. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwa - Waits River Formation, amphibolite and greenstone member (Lower Devonian and Silurian)

DSwa - Waits River Formation, amphibolite and greenstone member (Lower Devonian and upper Silurian)
Massive, dark-green to green, fine-grained, calcite-epidote-chlorite-biotite±hornblende±actinolite-plagioclase amphibolite and greenstone. The units is interpreted as mafic volcanic and volcaniclastic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSwa - Waits River Formation, amphibolite and greenstone member (Lower Devonian and Silurian)
Dark-green to green, fine-grained, massive epidote-chlorite-hornblende-plagioclase amphibolite with 1- to 3-mm-diameter, white, sausseritized plagioclase porphyroclasts and laminated to massive, epidote-carbonate-actinolite-chlorite-plagioclase greenstone. Generally, the laminated greenstone is intercalated with DSwv, and the massive greenstone and amphibolite have sharp contacts with adjacent units. In the northcentral part of the map, the greenstone is interlayered with DSwv on a 1- to 3-cm-scale over a distance of several meters along the contact. The amphibolite crops out in the west, where the rocks are at higher metamorphic grade and contain layers of greenstone similar to those found to the east. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

DSwss - Waits River Formation, sulfidic schist member (Lower Devonian and upper Silurian)

Silvery, rusty yellow weathering, sulfidic quartz-muscovite schist. The unit is interpreted as a hydrothermally produced stratoform sulfide deposit. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

DSn - Northfield Formation, schist member (Lower Devonian and upper Silurian)

Dark-gray to silvery gray, fine-grained, carbonaceous muscovite-biotite plagioclase-quartz schist or phyllite marked by conspicuous small garnets (1 to 2 mm in diameter) that form small bumps on the foliation surfaces. Commonly, garnets are partially to completely replaced by white plagioclase or chlorite. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Scq - Clough Quartzite, metaconglomerate and quartzite member (Silurian)

Scq - Clough Quartzite, conglomerate member (lower Silurian)
White, locally rusty weathering, massive, quartz-cobble metaconglomerate and lesser white quartzite. Locally contains ankerite or magnetite. Contains thin seams of silvery white, chloritoid-quartz-muscovite schist at French's Ledges. Cobbles consist largely of vein quartz and white and gray quartzite. Contacts with adjacent units are sharp and not intercalated. Typical exposures occur on French's Ledges and Smith Hill. Possibly occurs as olistoliths on the east side of French's Ledges where the Clough Quartzite is bounded on both sides by the melange unit DSm. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Scq - Clough Quartzite, metaconglomerate and quartzite member (Silurian)
Undifferentiated unit of (1) light-gray, orange- weathering, massive, poorly bedded, weakly foliated quartzite with minor muscovite; (2) gray to orange, well-bedded, micaceous quartzite with beds from 1 cm to 1 m thick; and (3) white to gray, muscovite-bearing, quartz-pebble to cobble metaconglomerate. Extremely rare, faintly visible crossbeds are locally preserved. Clasts are typically elongated (aspect ratios commonly exceeding 10:1) and consist dominantly of vein quartz and gray to white quartzite. Rare amphibolite (found at one location on the northwest side of Green Mountain) is mapped as Scd. Contacts are typically sharp. The unit may contain magnetite and, at higher metamorphic grades, it may contain chloritoid and garnet. Locally, the unit is mylonitic along the Northey Hill shear zone. Fossils present are described by Boucot and others (1958) and Boucot and Thompson (1963) and include tetracorals, brachiopods, pelecypods, and a possible trilobite; fossils support a Llandovery (early Silurian) age. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Scs - Clough Quartzite, rusty muscovite schist member (Silurian)

Scs - Clough Quartzite, rusty muscovite schist member (Lower Devonian and upper Silurian)
Rusty weathering, medium- to coarse-grained, chlorite-biotite-muscovite-quartz schist that typically contains staurolite and garnet porphyroblasts. Contacts with Scq are not exposed in the map area. The unit is mapped as discontinuous horizons along the ridge of Green Mountain. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Scms - Clough Quartzite, muscovite schist member (Silurian)

Scms - Clough Quartzite, muscovite schist member (Lower Devonian and upper Silurian)
Silvery to light-gray, medium-grained, garnet-muscovite-quartz schist with ubiquitous pink garnets. The unit occurs at the base of the Clough Quartzite at the contact with the Partridge Formation on Green Mountain, but the contact is not exposed in the map area. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ss - Shaw Mountain Formation (Silurian)

Heterogeneous unit consisting of interbedded rusty, slabby quartz-amphibolite, gray quartzite, feldspathic granofels, and biotite schist. The unit is exposed in Weathersfield on Pikes Peak. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oqd - Quartz diorite of the Lebanon dome (Late Ordovician)

Oqd - Oliverian Plutonic Suite, quartz diorite of the Lebanon dome (Late Ordovician)
Gray, weakly to moderately well foliated, blocky weathering, epidote-quartz-hornblende-biotite-

plagioclase quartz diorite gneiss. The quartz diorite intrudes the Partridge Formation in the northeastern part of the map. The contact is sharp and roughly parallel to the dominant foliation. The quartz diorite is well exposed in Lebanon at an abandoned quarry about 450 m west of Slayton Road. This unit is the border-phase of the Lebanon pluton, and it surrounds a core of pink biotite granite, which is not exposed in the area of this map; the latter is exposed in the adjacent Hanover quadrangle to the north (Kaiser, 1938; Lyons, 1955). Valley and Walsh (2013) report a preliminary U-Pb SHRIMP zircon age of about 447 Ma for the quartz diorite. At the dated sample locality In the Hanover quadrangle (Stop l of Walsh and others, 2012), the intruded Panridge Formation consists of rusty sulfidic, psammitic quartz-muscovite schist, which was not mapped separately in the area of this report. The schist in the North Hartland quadrangle is generally more pelitic than the rock at Stop 1 of Walsh and others (2012). Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Op - Partridge Formation, sulfidic schist member (Ordovician)

Op - Partridge Formation, sulfidic schist member (Ordovician)
Dark-gray to grayish-black, rusty- weathering, sulfidic, graphite±garnet-plagloclase-biotite-quartz-muscovite phyllite and schist: locally contains light- to dark-gray micaceous quartzite in thinly laminated layers or boudins. In Plainfield, south of Town Farm Road, an anomalous micaceous quartzite contains accessory graphite, hematite, and garnet in the biotite zone. Dark-gray quartzite beds as much as 30 cm thick occur locally. The unit contains lesser silvery gray garnet-muscovite-epidote-plagioclase-chlorite-biotite-quartz near the contact with the Ammonoosuc Volcanics. It also contains rare, light-gray and pale-yellow banded magnetite-muscovite-biotite-quartz-calcite-plagioclase-garnet coticule interlayered with magnetite-muscovite-quartz-plagioclase-biotite schist in the northeastern part of the map in Lebanon west of Storrs Hill. Contacts with the Ammonoosuc Volcanics are generally sharp, but may be gradational over a few meters. Contacts with the Clough Quartzite are very sharp. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Op - Partridge Formation, sulfidic schist member (Ordovician)
Dark-gray to light-gray and grayish-black, rusty weathering, sulfidic, graphite±garnet-ilmenite-plagioclase-biotite-chlorite-quartz-muscovite phyllite or schist. Contacts with the Ammonoosuc Volcanics are generally sharp, but may be gradational within a few meters. Contacts with the Clough Quartzite are very sharp and rocks are phyllonitic to mylonitic along the Northey Hill shear zone. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Opa - Partridge Formation, sulfidic schist member, amphibolite (Ordovician)

Opa - Partridge Formation, sulfidic schist member: coarse-grained hornblende-plagioclase amphibolite lenses and boudins (Ordovician)
The unit contains coarse-grained hornblende-plagioclase amphibolite lenses and boudins mapped as Opa at exposures under the power transmission lines on the west side of Farnum Hill. The amphibolites measure 0.2 to 1 m thick and their size is exaggerated on the map to show their locations. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Opa - Partridge Formation, sulfidic schist member, amphibolite (Ordovician)
Locally contains rare 1- to 3-m-thick, dark-green, epidote-chlorite-hornblende-plagioclase amphibolite dikes or metavolcanic layers (amphibolite) mapped as Opa. The size of the amphibolite (Opa) unit is exaggerated on the map to show location. Opa is only mapped at one location at the top of the Partridge Formation south of Bald Mountain. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Opq - Partridge Formation, sulfidic schist member, quartzite beds (Ordovician)

Locally, the unit contains light- to dark-gray micaceous quartzite (in thinly laminated layers or boudins) and dark-gray quartzite beds mapped separately as Opq. The size of the quartzite (Opq) unit is exaggerated on the map to show location. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Opp - Partridge Formation, plagioclase studded schist member (Ordovician)

Gray to light-gray, moderately well foliated to poorly foliated, quartz-biotite-epidote-plagioclase schist to granofels with abundant white plagioclase porphyroblasts consisting of recystrallized aggregates of plagioclase and granular epidote-clinozoisite. The unit is interpreted as a metasomatized version of the Partidge Formation sulfidic schist member (Op). The rock occurs discontinuously near the contact with the Lebanon quartz diorite. The metasomatized zone extends into the adjacent Hanover quadrangle (Kaiser, 1938; Lyons 1955); it was noted by Lyons but mapped differently. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Ogd - Granodiorite, trondhjemite, and tonalite of the Sugar River pluton (Ordovician)

Ogd - Oliverian Plutonic Suite, granodiorite, trondhjemite, and tonalite of the Sugar River pluton (Ordovician)
Gray, gray- to orange-weathering, fine- to medium-grained, ±garnet±hornblende-chlorite-biotite-K-feldspar/plagioclase-quartz granodiorite, trondhjemite, and tonalite. Accessory minerals include magnetite and apatite. Locally, the unit is enriched in magnetite near the contact with the Ammonoosuc Volcanics suggesting contact metasomatism. Enclaves and xenoliths of amphibolite are also present locally and indicate that the rocks intruded the Ammonoosuc Volcanics. The unit is mapped as the Sugar River pluton south of Green Mountain. A rock sample from the Sugar River pluton yielded a U-Pb SHRIMP zircon age of 460±3 Ma (Valley and others, 2019). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oa - Ammonoosuc Volcanics, heterogenous volcanic member (Ordovician)

Oa - Ammonoosuc Volcanics, undifferentiated volcanic member (Ordovician)
Heterogeneous complex of rock types consisting of layered to massive, greenstone, amphibolite, biotite-muscovite-chlorite-quartz-plagioclase schist and phyllite, felsic quartz-plagioclase granofels (metafelsite), and sulfidic quartz-plagioclase schist. May contain accessory calcite, ankerite, magnetite, or pyrite. The unit is dominated by mafic rocks, either volcanic or volcaniclastic. Metamorphic index minerals include hornblende and garnet in the garnet zone, and biotite and actinolite in the biotite zone; contains anomalous garnet in the biotite zone at one place in Hibbard Brook. Locally, the unit contains fascicular hornblende garbenschiefer in the garnet zone. At sub-garnet grade, the rocks are green, gray green, bluish green, silvery gray green, and green and white layered. In the garnet zone. the rocks are darker green, gray green to black, and black and white layered. Locally, the unit also contains pods and lenses of epidote, plagioclase, and lesser quartz phenocrysts, deformed pillows, fiamme (eutaxitic texture), and volcanic breccia. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oa - Ammonoosuc Volcanics, heterogenous volcanic member (Ordovician)
Undifferentiated assemblage of rock types consisting of (1) dark-greenish-gray, fine- to medium-grained, plagioclase-biotite-chlorite-quartz schist to phyllite; (2) layered to massive greenstone and

amphibolite (locally with garbenschiefer texture); (3) felsic quartz-plagioclase granofels (metafelsite); (4) limonite-muscovite quartzite; and (5) sulfidic quartz-plagioclase schist. Locally, the unit contains minor carbonate, magnetite, and sulfides. Below garnet grade, the rocks are green, gray-green, bluish-green, silvery gray green, and green and white layered. At or above the garnet zone, the rocks are darker green, gray green to black, and black and white layered. Locally, the unit also contains pods and lenses of epidote, plagioclase, quartz phenocrysts, deformed pillows, fiamme (eutaxitic texture), and volcanic breccia. The unit is interpreted as a heterogeneous, metamorphosed sequence of volcanic and volcaniclastic rocks, crystal tuffs, dacitic to andesitic flows, and mafic volcanic and volcaniclastic rocks. Internal contacts are variable and are either sharp or gradational by intercalation. Contacts with the Partridge Formation are generally sharp, but locally gradational. Along the Monroe thrust fault, the unit is in tectonic contact with the rocks of the Connecticut Valley trough. The unit is well exposed on Wellmans Hill and Barber Mountain. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oas - Ammonoosuc Volcanics, sulfidic schist member (Ordovician)

Dark-gray to light-gray and grayish-black, rusty weathering, sulfidic, graphite±garnet-ilmenite-plagioclase-biotite-chlorite-quartz-muscovite phyllite or schist. Resembles the Partridge Formation sulfidic schist member (Op) and may be correlative with it. The unit occurs on Dingleton Hill within the Cornish City belt of the Monroe thrust sheet. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oaf - Ammonoosuc Volcanics, metafelsite member (Ordovician)

Oaf - Ammonoosuc Volcanics, metafelsite member (Ordovician)
Pale-green to silvery light gray or white, light-gray to white to rusty weathering, laminated and well-foliated, ±biotite-muscovite-chlorite-quartz-plagioclase schist to protomylonite or granofels. Contains accessory magnetite and sulfides, local epidote and amphibole, and millimeter-size quartz and feldspar phenocrysts Contacts with the other units of the Ammonoosuc Volcanics are gradational. A belt of green and white banded rock on the west side of Fifield Hill is mapped separately as "Oafa", which contains metafelsite beds 5 to 30 cm thick interlayered with undifferentiated volcanic rocks. The contact along the Monroe fault is sharp and the metafelsite there is protomylonitic. Typical exposures of Oaf occur on the west side of Fifield Hill about 100 m east of Route 120. The unit is interpreted as felsic volcanic and volcaniclastic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oaf - Ammonoosuc Volcanics, metafelsite member (Ordovician)
Tan- to light-gray-weathering, ±muscovite-K-feldspar-chlorite-plagioclase-quartz schist, felsic granofels, felsic intrusive rocks, and minor quartz phenocryst-bearing rocks. The unit is interpreted as mostly felsic metavolcanics (some layers may represent intrusive sills) and is interlayered with other members of the Ammonoosuc Volcanics. The unit is well exposed in the southeast part of the Cornish City synform, on Ironwood Hill, and well-exposed on an unnamed hill 2 km north of Cornish City. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oafa - Ammonoosuc Volcanics, bimodal metavolcanic rocks member (Ordovician)

Oafa - Ammonoosuc Volcanics, metafelsite member with belt of green and white banded rock (Ordovician)
A belt of green and white banded rock on the west side of Fifield Hill is mapped separately (from Oaf) as Oafa, which contains metafelsite beds 5 to 30 cm thick interlayered with undifferentiated volcanic

rocks. The contact along the Monroe fault is sharp and the metafelsite there is protomylonitic. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oafa - Ammonoosuc Volcanics, bimodal metavolcanic rock member (Ordovician)
Green and white, dark-green, or black and white, distinctly banded, interlayered greenstone and metamorphosed felsic volcanic and intrusive rocks. Contacts are gradational with Oa and distinguished from Oa by the distinct alternating layering of felsic and mafic rocks which resemble Oaf and Oaa, respectively where mapped separately. The unit hosts an abandoned zinc-sulfur-pyrite mine on Hanover Street in Claremont, called the "Claremont Zinc Showing" (U.S. Geological Survey Mineral Resources Data System, record identification number 10093852, https://mrdata.usgs.gov/mrds/). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Oarr - Ammonoosuc Volcanics, rusty sulfidic granofels member (Ordovician)

Very light gray to silvery white, very rusty yellow weathering, well-foliated, sulfidic pyrite-muscovite-quartz-plagioclase granofels to schist. The unit is interlayered with the undifferentiated Oa unit on the east side of Fifield Hill in Plainfield. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oarq - Ammonoosuc Volcanics, lapilli tuff member (Ordovician)

Massive, pale-green to light-gray, gray weathering, muscovite-chlorite-biotite-quartz-plagioclase schist with white to light-gray felsic, flattened lapilli or lesser volcanic bombs as much as 10 cm long. May contain lesser, dark-gray-green mafic clasts. The matrix is aphanitic with millimeter-size quartz and feldspar phenocrysts. The unit occurs as layers within the undifferentiated Oa unit. Typical exposures occur under the power line at the summit of Pinnacle Hill and about 1 km east of Sky Ranch Pond, and just east of the summit of Colby Hill. The unit is interpreted as a pyroclastic volcanic rock. A SHRIMP U·Pb zircon age of 460:t2 Ma from Colby Hill indicates that part of the Ammonoosuc Volcanics in this area is younger than the Plainfield. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oag - Ammonoosuc Volcanics, felsic granofels member (Ordovician)

Massive, light-gray to very pale green. white· to tan-weathering. fine- to medium-grained, muscovite-chlorite-biotite-quartz-plagioclase granofels. Locally, contains millimeter- to centimeter-scale phenocrysts of quartz and feldspar and small centimeter-scale epidote pods. Contains accessory epidote, blue-green amphibole, and trace opaques. The unit is exposed in Plainfield on the west side of Ladieu Hill; typical exposures occur along Ladieu Road west of Colby Hill. The unit is interlayered with the Oa unit. The unit is interpreted as felsic volcanic and volcaniclastic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oaa - Ammonoosuc Volcanics, greenstone and amphibolite member (Ordovician)

Oaa - Ammonoosuc Volcanics, amphibolite member (Ordovician)
Massive to layered, gray-green to dark-green or black, fine-grained, apatite-calcite-actinolite-chlorite±biotite-epidote-hornblende-plagioclase amphibolite. The unit is exposed from Pinnacle Hill to the ridge east of Mud Pond, west of Porter Road. The unit is interpreted as mafic volcanic and volcaniclastic rock. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Oaa - Ammonoosuc Volcanics, greenstone and amphibolite member (Ordovician)
Dark-green to black, locally rusty weathering, massive to thickly layered, ±carbonate±magnetite-actinolite-epidote-plagioclase-chlorite greenstone, schistose greenstone, or amphibolite. Epidote nodules and layers are common, but the unit rarely contains deformed pillows that were observed along the power line northwest of Cornish City. The unit is interpreted to be submarine metabasalt, but may in part consist of mafic sills. At higher metamorphic grades, the rock contains appreciable amphibole, and locally it contains garbenschiefer texture; amphibolite is common south of Green Mountain. The unit is well exposed west of Cornish City and on Wellmans Hill. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ochg - Cram Hill Formation, greenstone member (Ordovician)

Medium-green to gray-green, well-foliated, hornblende-plagioclase greenstone that is marked by distinctive irregular clots, or indistinct patches of more plagioclase-rich inclusions (as much as 3 cm in length) that are set in a more uniform amphibolite matrix. The unit is interpreted as basaltic to andesitic tuff-breccia and volcaniclastic rock and is mapped at one location in Weathersfield, north of Route 131, where it occurs below the unconformity at the base of the Connecticut Valley trough. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ochv - Cram Hill Formation, felsic and mafic volcaniclastic rocks member (Ordovician)

Heterogeneous, metamorphosed volcaniclastic unit consisting of well layered, light-gray-weathering, felsic biotite-hornblende-quartz-plagioclase gneiss intricately interlayered with darker mafic, gray-green hornblende-biotite-plagioclase amphibolite and hornblende-plagioclase granofels and gneiss. The proportion of felsic to mafic layers varies greatly and the thickness of the mafic layers, which are generally subordinate, ranges from one to several meters; felsic layers range from internally laminated (on a cm scale) to more massive layers that are tens of meters or more thick. Rusty weathering biotite-muscovite-quartz schist, feldspathic granofels, and layers of coticule that are present throughout the unit indicate a collection of volcaniclastic rocks and interbedded subordinate metasedimentary rocks; for this reason the unit is interpreted as a member of the Cram Hill Formation. Contact relations with underlying units are uncertain, and it may disconformably overlie both the Moretown Formation and trondhjemite gneiss (Ontd) of the North River Igneous Suite. The unit occurs below the unconformity at the base of the Connecticut Valley trough. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ochq - Cram Hill Formation, quartzite member (Ordovician)

Steel-gray- to yellow-tan-weathering quartzite and quartz-pebble conglomerate as much as 2 m thick. At one location in Weathersfield, north of Route 131, the unit occurs along the contact with OCmb and Ochv. Description from source Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ot - Trondhjemite and tonalite (Ordovician)

Ot - Unnamed tonalite (Early Ordovician)
Light-gray to gray, light-gray weathering, well foliated, ±garnet±hornblende-biotite tonalite to trondhjemite and lesser biotite granite gneiss. Occurs as abundant foliation-parallel lit-par-lit dikes or sills in the Ammonoosuc Volcanics The map unit contains undifferentiated Ammonoosuc Volcanics, and is similar to and probably correlative with the Plainfield tonalite, but mapped bodies are not contiguous with the Plainfield pluton (Otp). The unit is well exposed in Lebanon at the Lebanon

Crushed Stone quarry on Mount Finish and at True's Ledges Natural Area along True's Brook (shown as Bloods Brook on the base map). Shown as polygonal map units or with strike and dip symbols; thickness is exaggerated on the map to show the location of zones of abundant dikes or sills. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Ot - Oliverian Plutonic Suite, trondhjemite and tonalite (Ordovician)
Light-gray to gray, very light gray to orange-weathering, medium-grained, ±garnet±hornblende±biotite-chlorite-plagioclase-quartz trondhjemite and tonalite. Locally, the unit contains characteristic small augen of quartz and lesser feldspar (up to 0.5 cm across). The unit occurs as abundant foliation-parallel lit-par-lit dikes or sills in the Ammonoosuc Volcanics in the central part of the map (mapped in the Cornish City belt, but not in the Claremont belt). The unit is similar to (and probably correlative with) the Plainfield tonalite in the adjacent North Hartland quadrangle (Walsh, 2016); there the tonalite yielded a U-Pb SHRIMP zircon age of 475±5 Ma (Valley and Walsh, 2013; Valley and others, 2019). The unit is well exposed on Wellmans Hill and southwest of Cornish City. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Otp - Plainfield tonalite (Early Ordovician)

Greenish-gray, light-gray weathering, moderately to weakly foliated, epidote±hornblende-biotite-chlorite-quartz-plagioclase tonalite to trondhjemite gneiss. Contains characteristic small augen of quartz and lesser feldspar, up to 0.5 cm across, and accessory calcite and muscovite. Chlorite is a product of retrograded biotite. Lyons (1955) first mapped this rock as the "gneiss east of Plainfield" and noted the similarity between this rock and the tonalitic "gneiss at White River Junction" Lyons considered the Plainfield tonalite to be conformable with the surrounding volcanic rocks, but new mapping shows that it is intrusive into the Ammonoosuc Volcanics, at least along the western side. The unit contains screens and xenoliths of the Ammonoosuc Volcanics. Good intrusive contacts are exposed along the power line on the southeast side of Stone House Hill (Walsh and others, 2012) and along Black Hill Road southeast of Sky Ranch Pond. Valley and Walsh (2013) report a preliminary U-Pb SHRIMP zircon age of 473±5 Ma for the tonalite. Description from source map: Hartland and Hartland North Quadrangles (Bedrock)

Ontd - Trondhjemite gneiss (Ordovician)

Ontd - Northern River Igneous Suite, trondhjemite gneiss (Ordovician)
Light-gray- to chalky-white-weathering, massive, medium-grained, biotite±garnet-quartz-plagioclase trondhjemite gneiss. The unit lacks mafic layers that are present in Ochv of the Cram Hill Formation and is interpreted as intrusive into Omhfs of the Moretown Formation along the contact with Ochv. Alternatively, this unit could be a metadacite. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmhfs - Moretown Formation, hornblende fascicle schist member (Cambrian to Ordovician)

OCmhfs - Moretown Formation, hornblende fascicle schist member (Ordovician to Cambrian)
Light-gray to gray-green, chlorite-muscovite-biotite-plagioclase-quartz schist and granofels characterized by (1) conspicuous sprays of hornblende; (2) distinctive, large (5-mm- to 1-cm-diameter) porphyroblasts of cross-foliation biotite; (3) abundant irregular layers of coticule that are 1 to 2 cm thick; and (4) abundant layers of light-gray, pinstriped biotite-quartz granofels similar to the “pinstriped” granofels member (Omp) of Ratcliffe and others (2011). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmb - Moretown Formation, black schist member (Cambrian to Ordovician)

Dark-gray to silvery gray, carbonaceous garnet-biotite-muscovite schist, and associated rusty weathering muscovite-biotite-quartz schist. The unit contains layers rich in small garnet that are 1 to 2 mm in diameter; layers resemble phyllites of the Whetstone Hill Member of the Moretown Formation (Ratcliffe and others, 2011). Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmgt - Moretown Formation, garnet schist and granofels (Cambrian to Ordovician)

Light-gray to gray-green-weathering, garnet-biotite-chlorite-muscovite-quartz schist and schistose biotite-garnet-plagioclase-quartz granofels with distinctive garnet. The unit occurs in depositional contact with OCmb about 1 km west of Brownsville in the northwest part of the map. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmrq - Moretown Formation, quartzite member (Cambrian to Ordovician)

Light-tan-weathering, thinly layered, muscovite-biotite-plagioclase quartzite. The unit occurs in contact with OCmgt as layers within OCmb. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCu - Talc-carbonate schist (Cambrian to Ordovician)

OCu - Talc-carbonate schist (Ordovician and Cambrian)
Cream-colored to light-bluish-gray, brown-weathering, talc-carbonate schist and dark-green serpentinite. The unit is exposed at one location in the black schist member (Omb) of the Moretown Formation south of Cady Hill Road in Weathersfield. The contacts with other units are not exposed in the map area. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmfs - Moretown Formation, green schist and granofels member (Cambrian to Ordovician)

OCmfs - Moretown Formation, green schist and granofels member (Ordovician to Cambrian)
Light-green to pale-gray-green, lustrous, chlorite-biotite-muscovite-quartz schist and light-gray feldspathic granofels interbedded on a scale of 10 cm. Locally, the unit contains coarse-grained garnet schist and widespread thin beds (as much as 10 cm thick) of pinstriped chlorite-muscovite-plagioclase-quartz schist and granofels identical to the “pinstriped” granofels member (Omp) of Ratcliffe and others (2011). Beds of coticule that are 1 to 2 cm thick or layers of dark-green, well-foliated amphibolite may be abundant. Distinctive porphyroblasts of cross-foliation biotite occur throughout the unit. These porphyroblasts and the very feldspathic interbeds are regionally characteristic of the Moretown or Stowe Formations and are absent from the Pinney Hollow Formation at the type locality and are also absent regionally (Ratcliffe and others, 2011) with which these rocks have been correlated by Thompson and others (1993). The unit is in fault contact with Mesoproterozoic rocks at its base and is interbedded with and gradational upward into OCmb. The unit is well exposed northeast and southeast of Ascutney Notch where it was intruded by the Cretaceous gabbro and diorite of the Little Ascutney stock.Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCmfsc - Moretown Formation, green schist and granofels member, coticule beds (Cambrian to Ordovician)

c - Moretown Formation, green schist and granofels member, coticule beds (Ordovician to Cambrian)
Beds of coticule that are 1 to 2 cm thick may be abundant. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

OCma - Moretown Formation, amphibolite (Cambrian to Ordovician)

OCma - Moretown Formation, amphibolite (Ordovician to Cambrian)
Dark-green epidote-biotite-hornblende and hornblende-plagioclase amphibolite. The rock varies from well foliated (with epidote pods) to a more granular rock consisting of approximately 70 percent hornblende and 30 percent plagioclase. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Y1bm - Baileys Mills tonalitic gneiss (Mesoproterozoic)

Y1bm - Mount Holly Complex, tonalitic gneiss (Mesoproterozoic)
Light-gray- to whitish-gray-weathering, coarse-biotite-flecked, medium-grained, biotite-quartz-plagioclase gneiss having a distinctive non-gneissic, igneous-appearing texture in less sheared rocks. The unit contains numerous inclusions of coarse biotite amphibolite (mapped as Ya) that may, in part, be comagmatic dikes of metagabbro. The unit passes into lighter-gray (more leucocratic) biotite trondhjemite gneiss, and yielded a SHRIMP U-Pb zircon age of 1,383±13 Ma (Ratcliffe and others, 1991; Aleinikoff and others, 2011). The unit is well exposed along the power line southwest of Nelsons Corner. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Y1bmp - Baileys Mills plagioclase-phenocrystic tonalite gneiss (Mesoproterozoic)

Y1bmp - Mount Holly Complex, plagioclase-phenocrystic tonalite gneiss (Mesoproterozoic)
Very well foliated, mylonitic, biotite gneiss containing porphyroclastic eyes of plagioclase (as much as 5 mm long) that are set in a mylonitic matrix that is rich in biotite. The rock gradually passes into a mylonite gneiss or schist that may be equivalent to much of the dark, biotitic, feldspathic schist in the feldspathic member of the Cavendish Formation (Ycfs) on Hawks Mountain and on Pine Hill in the adjacent Chester quadrangle (Ratcliffe, 1995b; 2000b). The unit is well exposed along the power line southeast of Nelsons Corner. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ycfs - Cavendish Formation, feldspathic schist or granofels (Mesoproterozoic)

Ycfs - Mount Holly Complex, Cavendish Formation, feldspathic schist or granofels (Mesoproterozoic)
Either (1) light-to medium-dark gray, rusty weathering, white-plagioclase-spotted, biotite-quartz granofels; or (2) biotite-rich porphyroclastic schist that has isolated augen of plagioclase (as much as 1 cm in diameter) that are set in a phyllonitic matrix of biotite, muscovite, epidote, and quartz.

Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ycm - Cavendish Formation, marble (Mesoproterozoic)

Ycm - Mount Holly Complex, Cavendish Formation Marble (Mesoproterozoic)
Unit consisting of a variety of marbles closely associated with calc-silicate gneiss and (or) beds of actinolitic quartzite, including (1) whitish-gray-weathering, medium- to coarse grained, phlogopite-calcite-dolomite and quartz-knotted marble; (2) greenish actinolite-rich dolomitic marble; and (3) yellow-gray weathering, fine-grained, highly foliated phlogopite-talc(?)-tremolitedolomite marble. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ybg - Biotite-quartz-plagioclase-gneiss (Mesoproterozoic)

Ybg - Mount Holly Complex, biotite-quartz-plagioclase-gneiss (Mesoproterozoic)
Heterogeneous unit consisting of an assemblage of dark- to medium-gray, non-rusty weathering, quartz-rich biotite gneisses, all characterized by abundant plagioclase and epidote and little or no microcline. Other distinctive rock types include (1) light-gray-weathering, magnetite-muscovite-biotite-plagioclase-quartz gneiss containing thin layers of hornblende spotted gneiss; (2) very dark gray, biotite-rich plagioclase-quartz gneiss commonly associated with epidote quartzite; and (3) medium to dark-gray, white-albite-spotted, biotite-quartz gneiss. Muscovite is a common accessory mineral in most rocks and small garnet may be present as well. The biotite-quartz-plagioclase gneiss contains numerous layers of other distinctive rocks interlayered throughout; where these interlayered rocks are thick enough, they are mapped separately as Ya and Y2rs. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Ya - Amphibolite (Mesoproterozoic)

Ya - Mount Holly Complex, amphibolite (Mesoproterozoic)
Dark-green- to dull-gray-weathering, fine- to coarse-grained, biotite-hornblende-plagioclase and garnet-hornblende-plagioclase amphibolite that is commonly associated with Y2rs or Ybg. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

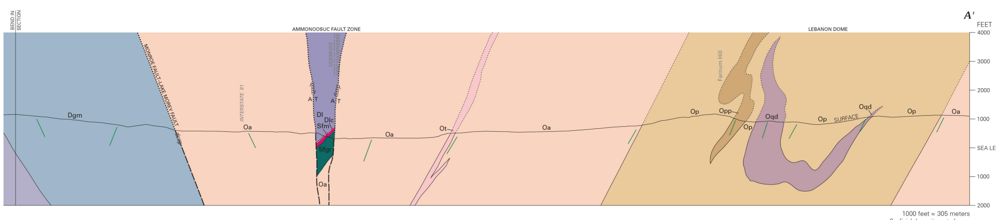
Y2rs - Quartz schist and gneiss (Mesoproterozoic)

Y2rs - Mount Holly Complex, quartz schist and gneiss (Mesoproterozoic)
Dark-brown to gray, rusty weathering, gneiss and schist containing abundant layers of schistose quartzite, biotite-garnet quartzite, and rusty sulfidic amphibolite. Locally, the rock passes into more muscovitic, lustrous, chlorite-garnet-muscovite schist mapped in the adjacent Chester and Cavendish quadrangles as unit Yrs (Ratcliffe, 1995a; 1995b; 2000a; 2000b), but here they are not distinguished separately. Description from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Geologic Cross Sections

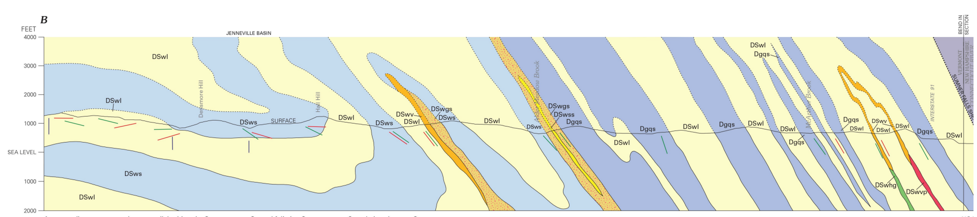
The geologic cross sections present in the GRI digital geologic-GIS data produced for Saint-Gaudens National Historical Park, New Hampshire (SAGA) are presented below. Note that some cross section abbreviations (e.g., A - A') have been changed from their source map abbreviation in the GRI data so that each cross section abbreviation in the GRI data is unique. Changes in cross section abbreviation are noted with each section. Cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document). As the cross section graphics are wide each cross section graphic has been split into two graphics. This was done near the "Bend in Section" of a cross section with some overlap between the two graphics. For cross sections E-E' and F-F', the graphic was split near the middle of the graphic. No vertical exaggeration is present on any cross section.

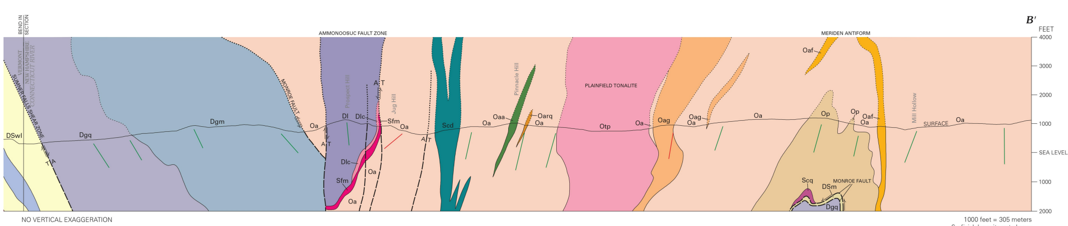
Cross Section A-A'



Cross section from source map: [Hartland and Hartland North Quadrangles (Bedrock)].

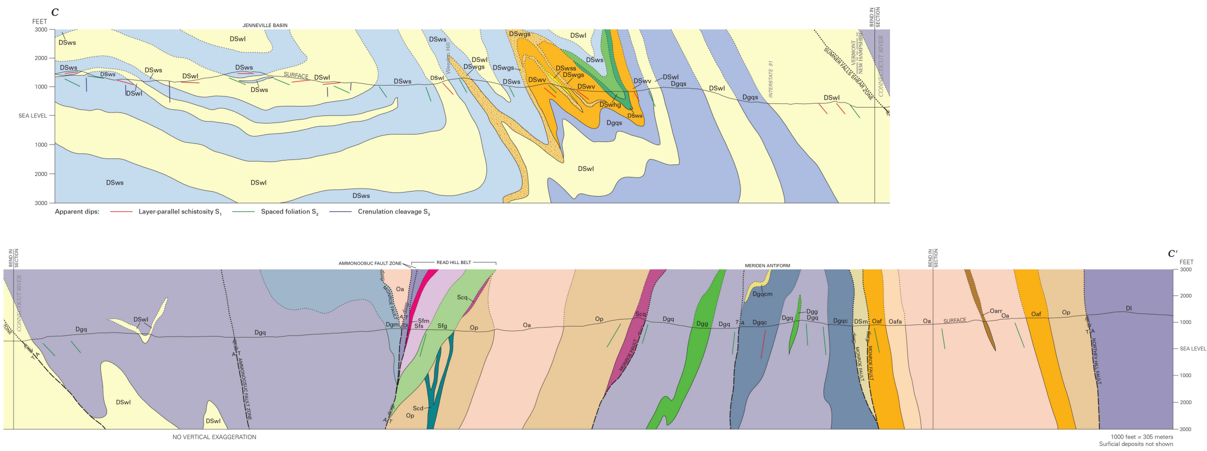
Cross Section B-B'





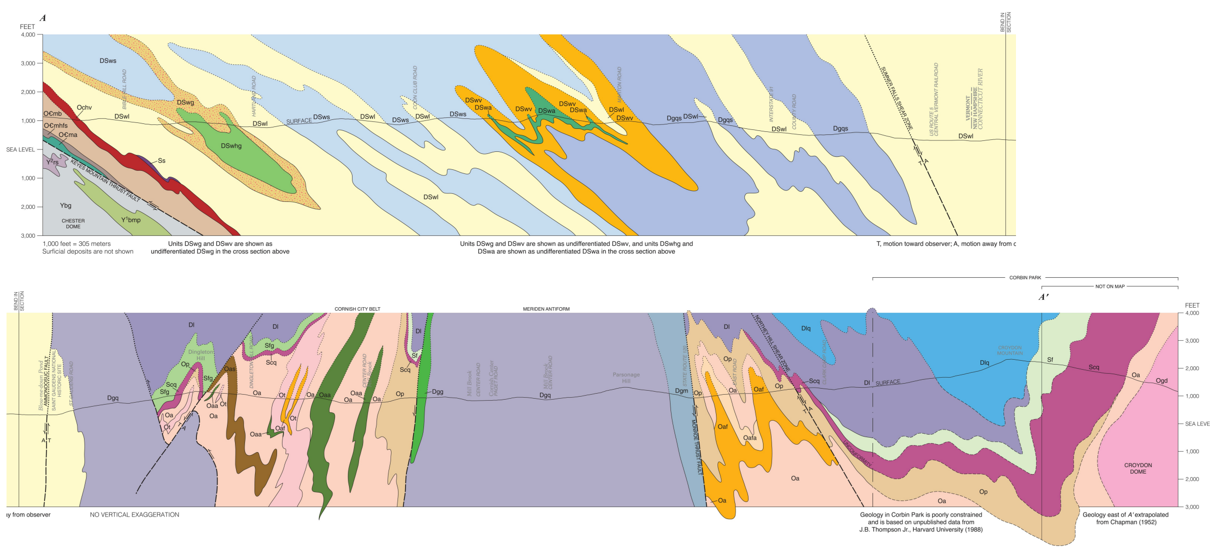
Cross section from source map: [Hartland and Hartland North Quadrangles (Bedrock)].

Cross Section C-C'



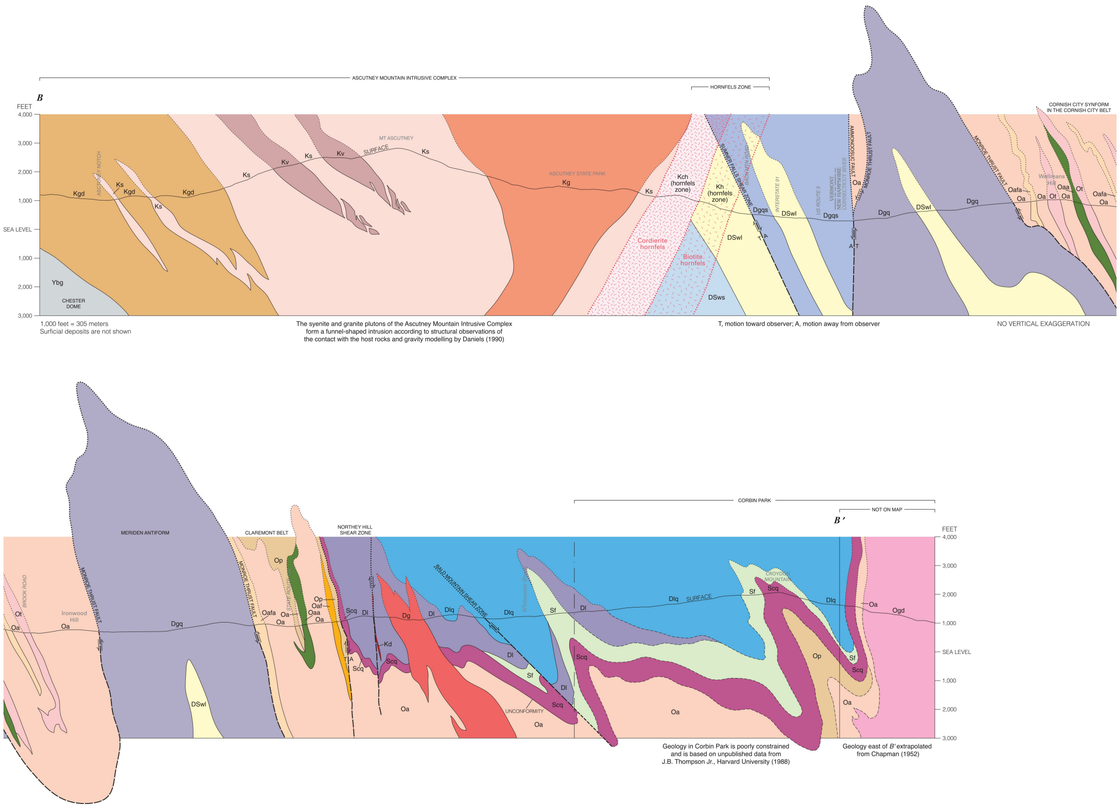
Cross section from source map: Hartland and Hartland North Quadrangles (Bedrock).

Cross Section D-D'



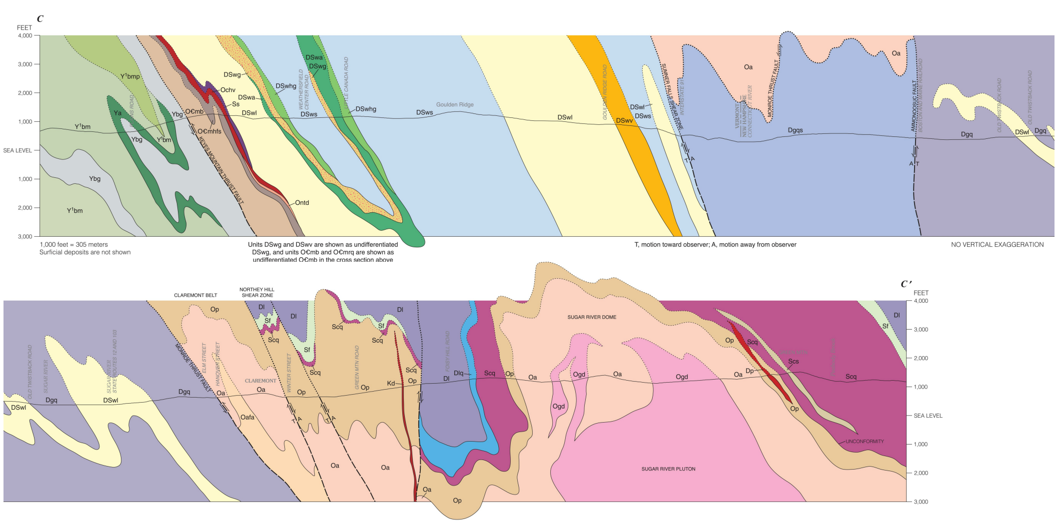
Cross section from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock). Cross section A-A' on source map.

Cross Section E-E'



Cross section from source map: [Mount Ascutney 7.5'x15' Quadrangle (Bedrock)](). Cross section B-B' on source map.

Cross Section F-F'



Cross section from source map: [Mount Ascutney 7.5'x15' Quadrangle (Bedrock)](). Cross section C-C' on source map.

Photographs

Photographs pertaining to photograph locations in the Geologic Observation Localities data layers in the GRI digital geologic-GIS data can be obtained on the U.S. Geological Survey Publications Warehouse at the following web sites:

Hartland and North Hartland (SIM-3361): https://pubs.er.usgs.gov/publication/sim3361

Mount Ascutney (SIM-3340): https://pubs.er.usgs.gov/publication/sim34400

Photographs are referenced by their Location ID plus ".jpg" (e.g., HA-002_1.jpg). This information (photograph file names) is present in the Notes fields associated with each photograph location. In some cases a photograph file name is missing the initial letters associated with its Location ID (e.g., photographs linked to Location ID CN-3301 have file names without the "CN-"). Note that some locations have multiple photographs (denoted with "_1", "_2" etc.).

Ancillary Source Map Information

The following sections present ancillary source map information associated with source maps used for this project.

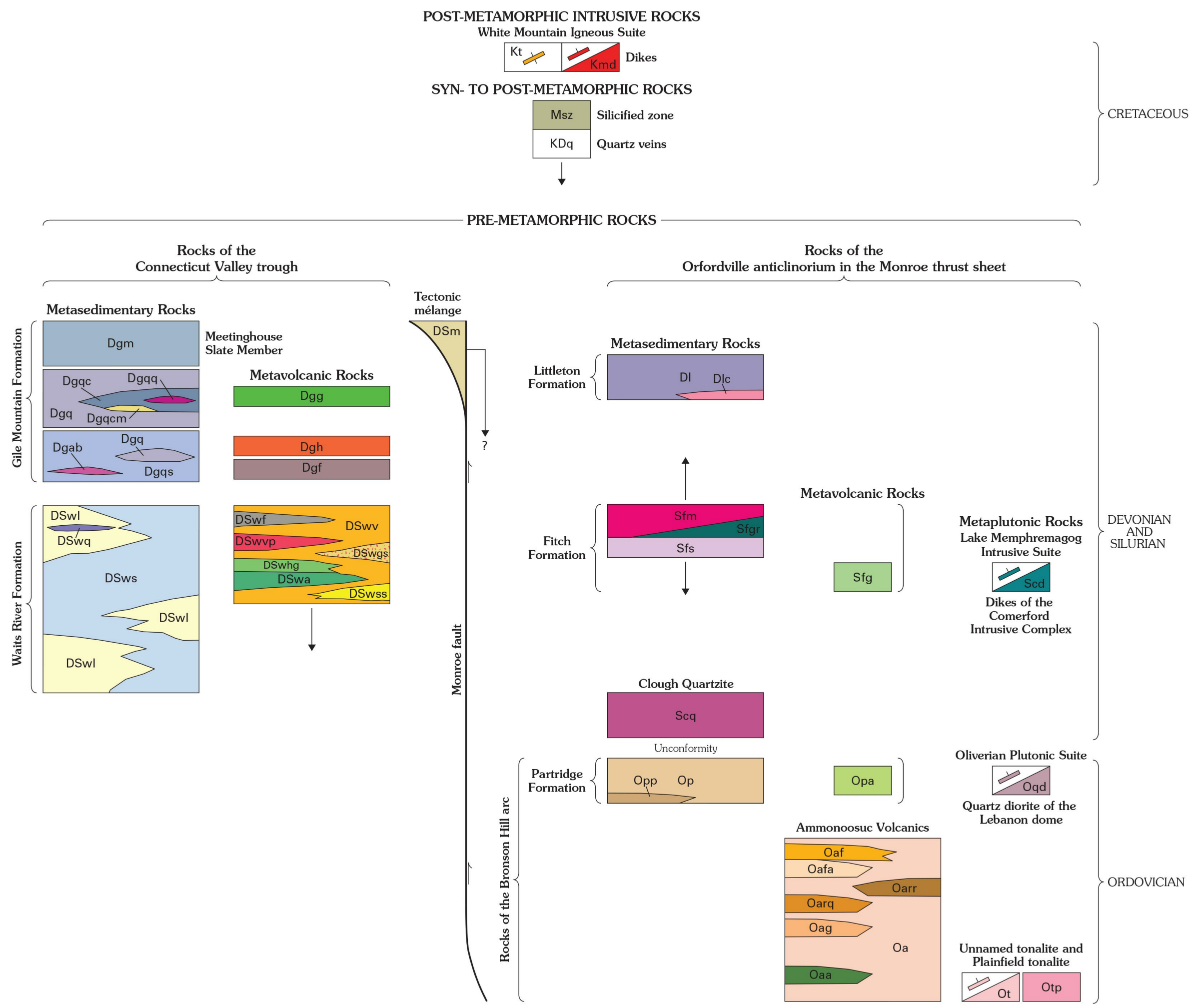
Hartland and Hartland North Quadrangles (Bedrock)

The formal citation for this source.

Walsh, G.J., 2016, Bedrock geologic map of the Hartland and North Hartland Quadrangles, Windsor County, Vermont, and Sullivan and Grafton Counties, New Hampshire: U.S. Geological Survey, Scientific Investigations Map SIM-3361, scale 1:24,000 (*GRI Source Map ID 76011*).

Prominent graphics and text associated with this source.

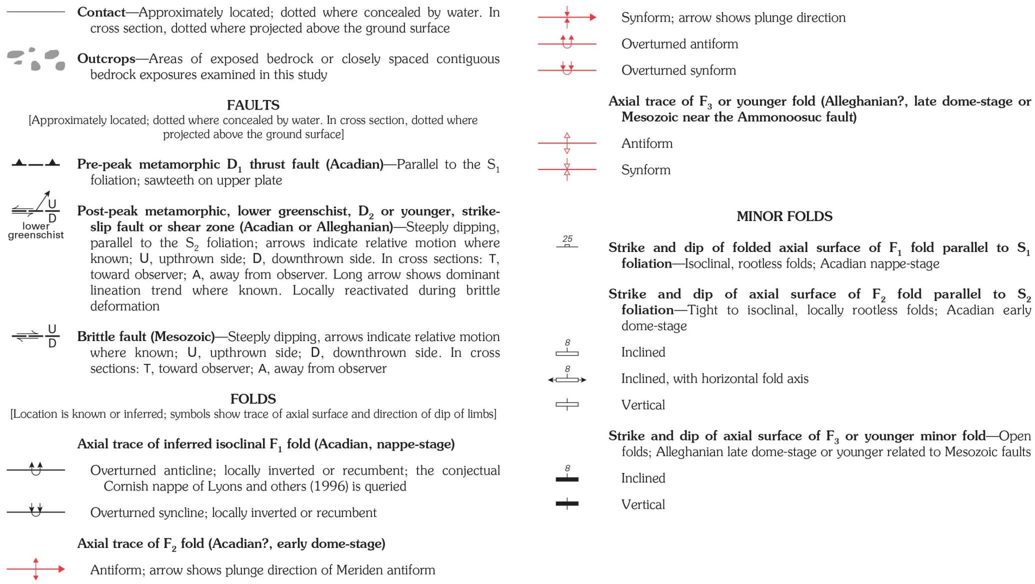
Correlation of Map Units



Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

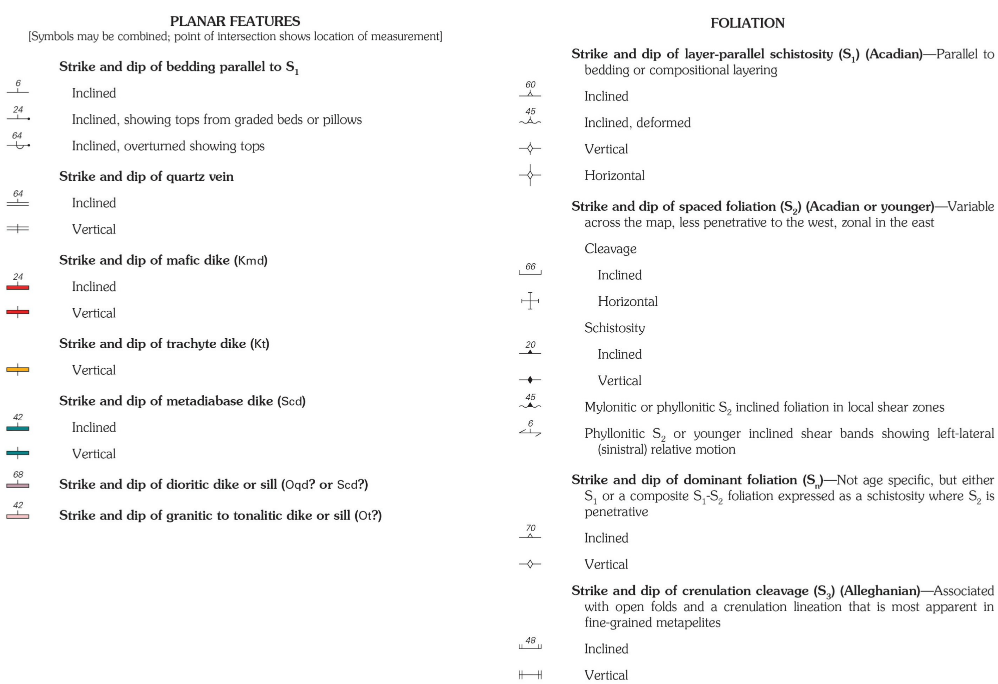
Map Legend

Contacts, Outcrops, Faults, Folds and Minor Folds



Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

Planar Features and Foliation



Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

Linear Features and Other Features

LINEAR FEATURES

[Symbols may be combined; point of intersection shows location of measurement]

1 **Approximate bearing and plunge of folded F_1 minor fold axis**

28 **Bearing and plunge of L_2 intersection lineation**—Intersection between the S_2 and S_1 foliations

54 **Bearing and plunge of F_2 minor fold axis**—Fold axis of tight, isoclinal, or rootless fold associated with S_2

60 **Bearing and plunge of L_2 mineral lineation**—Aggregate lineation or grain lineation associated with the S_2 foliation; consists of quartz, plagioclase, biotite, muscovite, chlorite, or amphibole

32 **Bearing and plunge of L_2 rods or object lineations**—Lineations composed of elongate objects such as pebbles and quartz or plagioclase phenocrysts; lineation generally associated with the S_2 foliation but may represent an older L_1 lineation

23 **Bearing and plunge of F_3 minor fold axis**—Fold axis of late, open fold or crenulation lineation

OTHER FEATURES

Garnet / Biotite **Isograd or tectonic metamorphic boundary**—Approximate boundary between rocks with garnet and (or) hornblende in the garnet zone versus rocks with biotite and (or) actinolite, or locally chloritoid (in Scq), in the biotite zone. The boundary locally coincides with splays of the Ammonoosuc or Northey Hill faults

Quarry

Active—Construction aggregate in the Ammonoosuc Volcanics

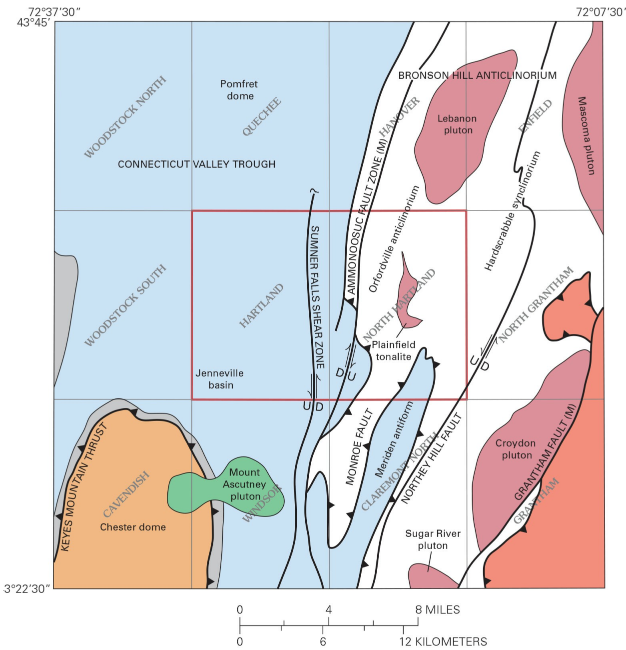
Abandoned

Spring

NH–144 475±5 Ma **Geochronology sample location**—Showing sample number and preliminary uranium-lead (U-Pb) zircon age in millions of years before present (Ma, mega annum) by sensitive high resolution ion microprobe (SHRIMP) from Valley and Walsh (2013) and Valley and others (2015)

Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

Figure 1 (sheet 1) - Simplified Tectonic Map



EXPLANATION

- **White Mountain Igneous Suite (Cretaceous)**
- **New Hampshire Plutonic Suite (Devonian)**
- **Connecticut Valley trough (Devonian and Silurian)**
- **Bronson Hill anticlinorium (Devonian to Ordovician)**
- **Oliverian Plutonic Suite (Ordovician)**
- **Rowe-Hawley zone (Ordovician and Late Cambrian)**
- **Basement rocks (Mesoproterozoic)**
- **Contact**
- **Thrust fault**—Sawteeth on upper plate
- U/D **Post-peak metamorphic fault**—Arrows indicate relative motion; U, upthrown side; D, downthrown side. Abbreviation: M, Mesozoic

Figure 1.—Simplified tectonic map and index to 7.5-minute quadrangles (in gray). Modified from Ratcliffe and others (2011) and Lyons and others (1997). The area of this report is outlined in red.

Graphic from source map: [Hartland and Hartland North Quadrangles (Bedrock)]

Figure 1 (sheet 2) - Tectonic Map

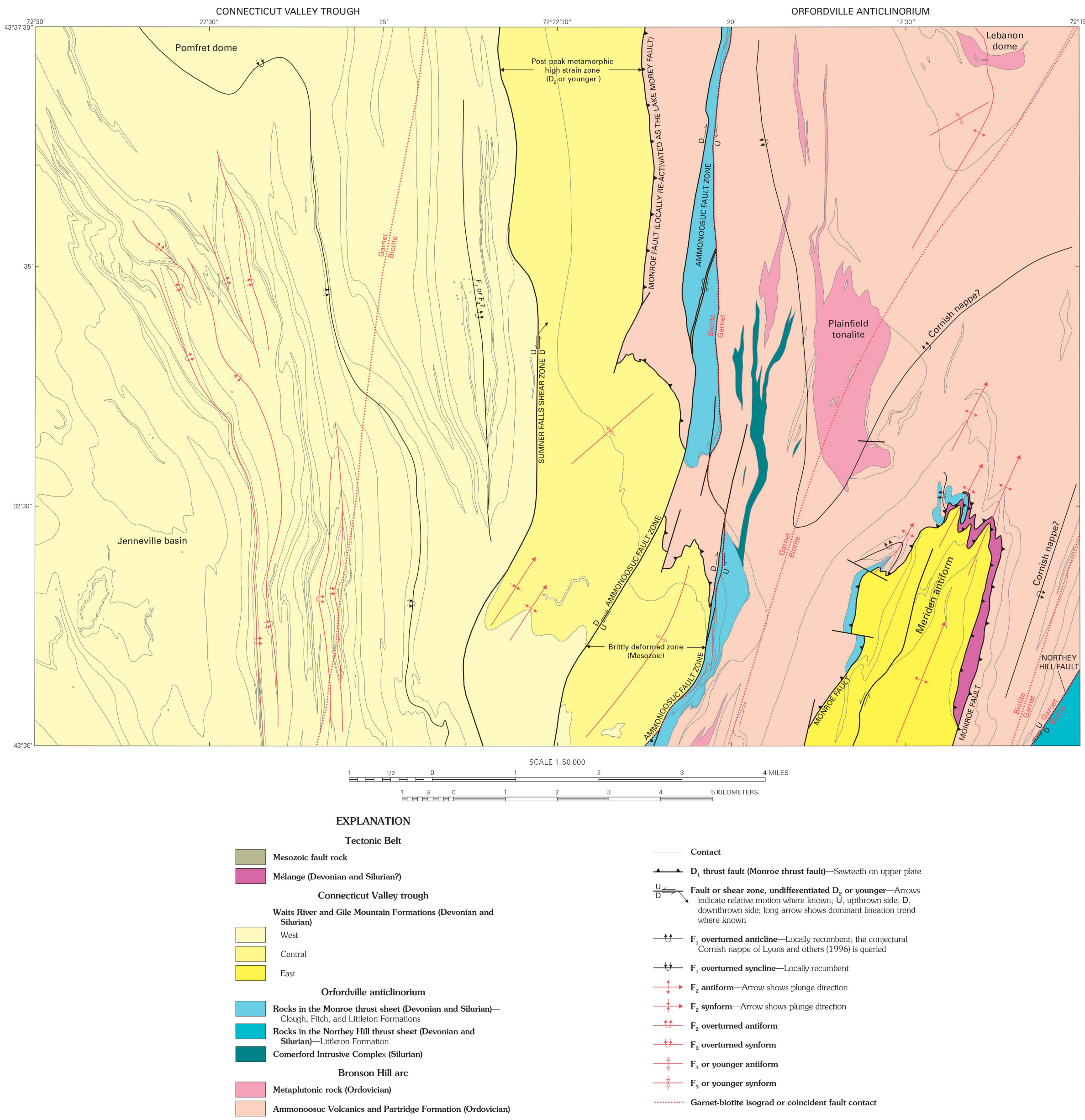


Figure 1.—Tectonic map showing major structural features of the Hartland and North Hartland quadrangles.

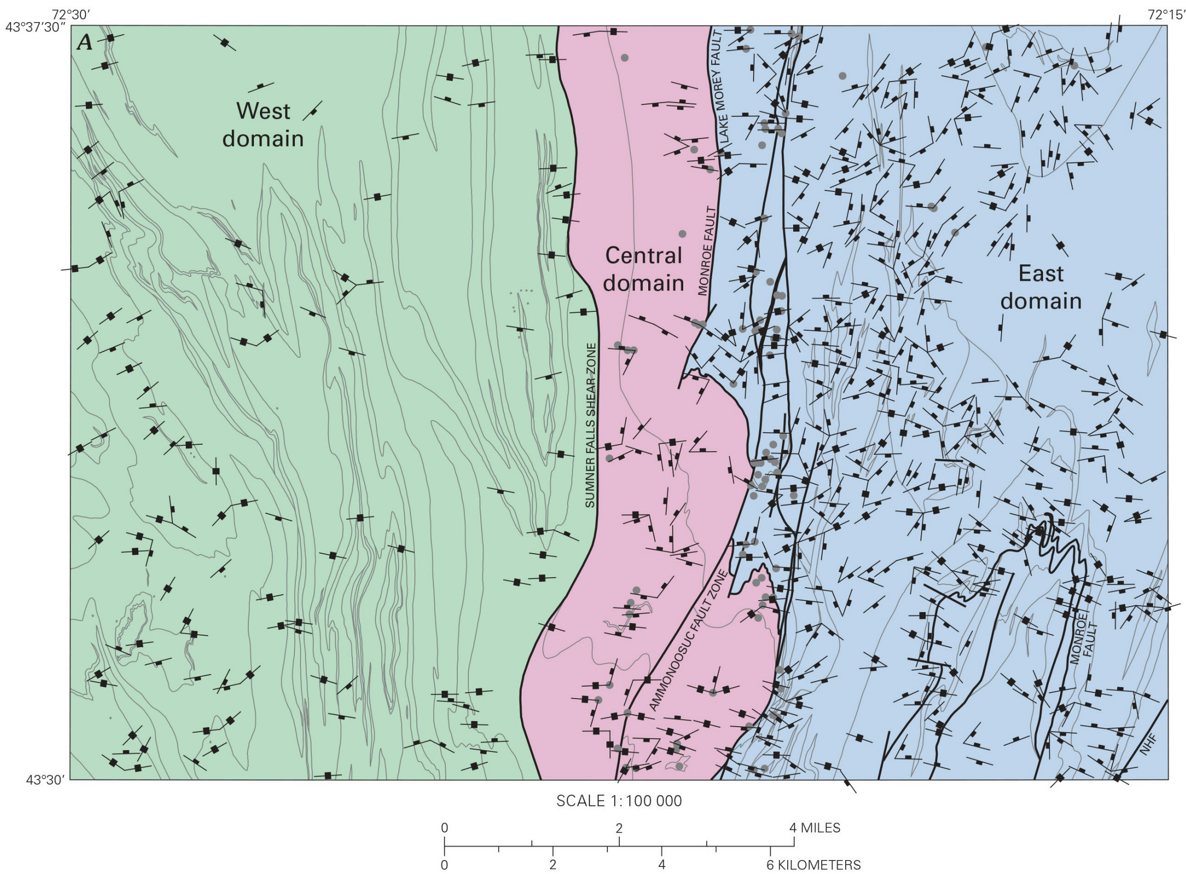
Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

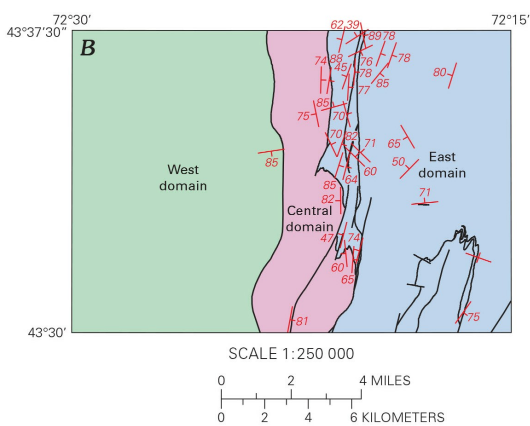
Figure 2 (sheet 2) - Structure Domain Maps and Stereonets

Structural domain maps of the Hartland and North Hartland quadrangles showing the orientation and distribution of representative measured brittle features; consult the GIS database for the complete data, which are not plotted here due to cartographic constraints. Structural domains are divided by the Sumner Falls shear zone (divides west and central domains) and the Monroe fault and Ammonoosuc fault zone (divides central and east domains). A, Locations and data results for measured outcrop-scale joints and kink bands. Results for measured joint data are summarized on three pairs of diagrams (at top) separated into three structural domains: west, central, and east. Each pair includes a stereonet and a rose diagram. Results for measured kink bands include all three structural domains shown on one stereonet and rose diagram (to the left of map A). The greater number of joint measurements in the east domain reflects recent efforts to collect more data than in the previous study by Walsh (1998), and does not indicate that the rocks are more jointed in the east. B, Locations and data results for measured outcrop-scale brittle faults. Results for measured brittle faults include all three structural domains shown on one stereonet and rose diagram (map B). For all stereonets for A and B, contoured poles to the associated brittle features are shown along with the strike and dip orientations for poles to the principal planes in the dataset. For all rose diagrams for A and B a normalized subset of the data is shown in the corresponding stereonet for dips >59°, and principal peaks are shown with 1 standard deviation error (for example, 282°±16° for the joints in the east domain). The number of data points is indicated by “n” at the bottom of each diagram. Stereonets and rose diagrams were plotted using the Structural Data Integrated System Analyser (DAISY, version 4.95.05) software by Salvini and others (1999) and Salvini (2013). Abbreviation: NHF, Northey Hill fault.

Figure text from source map: Hartland and Hartland North Quadrangles (Bedrock)

Figure 2 (sheet 2) - Domain Maps





EXPLANATION

Structural domain

- West
- Central
- East

Contact (fig. 2*A*)

Fault

Strike and dip direction of representative joints (fig. 2*A*)

- Inclined
- Vertical

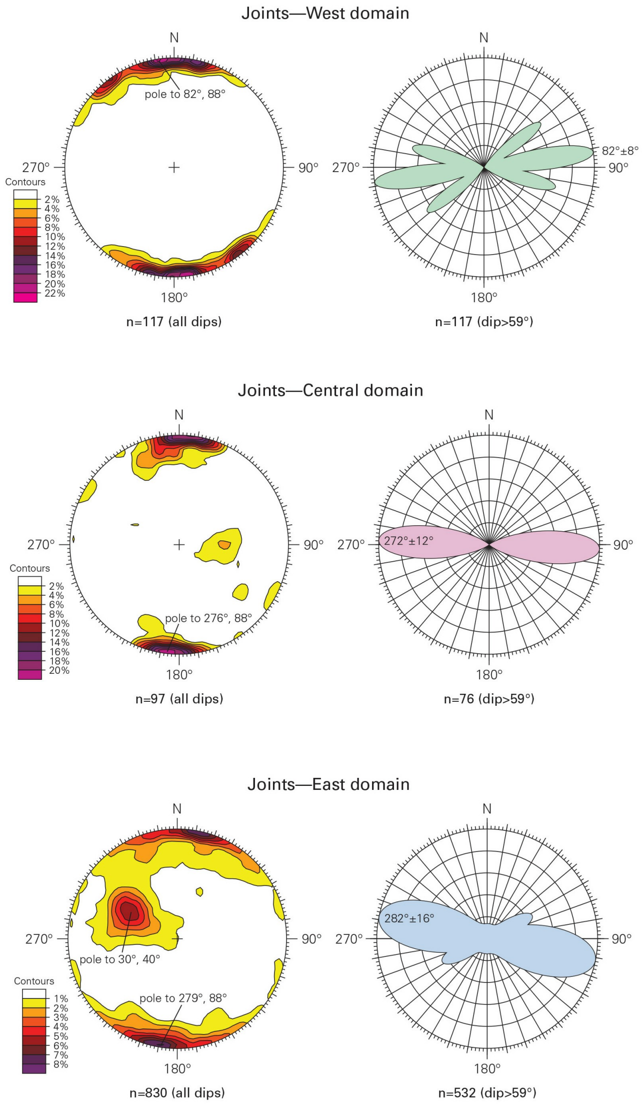
Location of measured kink bands—Spatially associated with mapped brittle faults (fig. 2*A*)

Strike and dip direction of representative brittle fault plane (fig. 2*B*)

- 85 Inclined
- Vertical

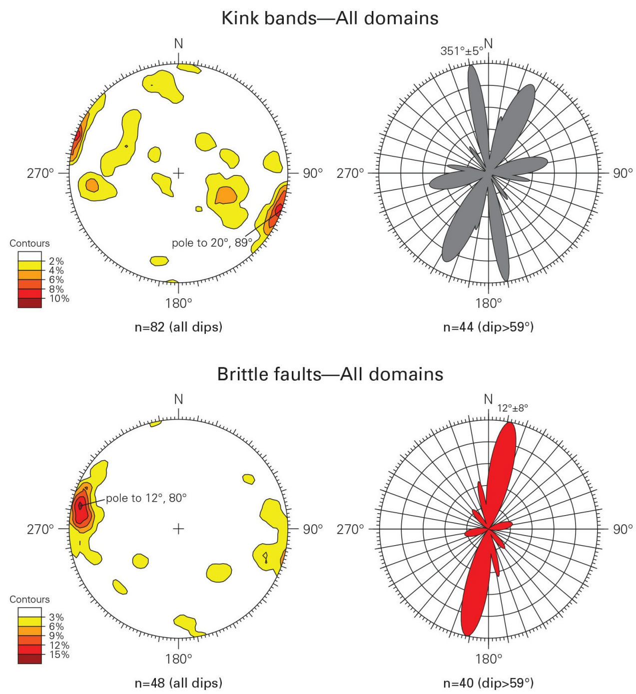
Graphic from source map: Hartland and Hartland North Quadrangles (Bedrock)

Figure 2 (sheet 2) - Joint Stereonets



Graphic from source map: [Hartland and Hartland North Quadrangles (Bedrock)]

Figure 2 (sheet 2) - Kink Band and Brittle Fault Stereonets



Graphic from source map: [Hartland and Hartland North Quadrangles (Bedrock)]

Discussion

INTRODUCTION

The bedrock geology of the 7.5-minute Hartland and North Hartland quadrangles, Vermont-New Hampshire, consists of highly deformed and metamorphosed lower Paleozoic metasedimentary, metavolcanic, and metaplutonic rocks of the Bronson Hill anticlinorium (BHA) and the Connecticut Valley trough (CVT) (Lyons and others, 1997; Ratcliffe and others, 2011; Walsh and others, 2012, 2014). Rocks of the Orfordville anticlinorium on this map occupy the western part of the broader BHA. In the BHA, the Ordovician Ammonoosuc Volcanics and graphitic, sulfidic metapelite of the Partridge Formation are intruded by Ordovician plutonic rocks of the Oliverian Plutonic Suite. The Ordovician rocks are collectively referred to as the Bronson Hill arc. The Ordovician rocks are overlain by Silurian to Devonian Clough, Fitch, and Littleton Formations (Lyons and others, 1997). On this map, rocks of the CVT occupy the eastern part of the broader CVT. In the CVT in Vermont, the Silurian to Devonian Shaw Mountain, Waits River, and Gile Mountain Formations form an unconformable autochthonous to parautochthonous cover sequence on the pre-Silurian rocks of the Rowe-Hawley zone above Precambrian basement rocks of the Mount Holly Complex (Ratcliffe and others, 2011). On this map, however, only the Waits River and Gile Mountain Formations are exposed. Syn- to postmetamorphic rocks include quartz veins and Cretaceous dikes of the White Mountain Igneous Suite.

Rocks of the BHA occur in a thrust sheet floored by the Monroe fault, which carried a deformed section of plutonic rocks, Ammonoosuc Volcanics, Partridge Formation, Clough Quartzite, and the Fitch and Littleton Formations. The Monroe thrust sheet placed the BHA rocks over the CVT during an early Acadian F1 nappe-stage event prior to peak metamorphism at lower amphibolite facies conditions. Upper and lower plate truncations, mylonite, and local melange characterize the Monroe fault. F2 doming deformed the Monroe thrust sheet, folded earlier isograds, and created the Meriden antiform and Lebanon dome. Lower greenschist facies (Acadian to Alleghanian) faults such as the Sumner Falls shear zone truncated peak-metamorphic assemblages, isograds, and older F1 folds and faults. Late-stage F3 folds show preferred left-lateral rotation sense (see Orientation Points in the database) and are probably related to late dome-stage Alleghanian deformation or motion along lower greenschist facies faults. The youngest deformation is characterized by Mesozoic brittle faulting and spatially associated kink bands along the Ammonoosuc fault zone, followed by subsequent jointing.

Currently major economic natural resource activities are related to aggregate quarrying in the Ammonoosuc Volcanics at Twin State Sand and Gravel in Hartford, Vt., and Lebanon Crushed Stone in Lebanon, N.H.

ACKNOWLEDGMENTS
Partial funding for this map came from the National Park Service. Helpful review comments were provided by P.M. Valley (U.S. Geological Survey), A.J. Merschat (U.S. Geological Survey), and P.J. Thompson (University of New Hampshire).

Text from source map: Hartland and Hartland North Quadrangles (Bedrock)

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Text from source map: Hartland and Hartland North Quadrangles (Bedrock)

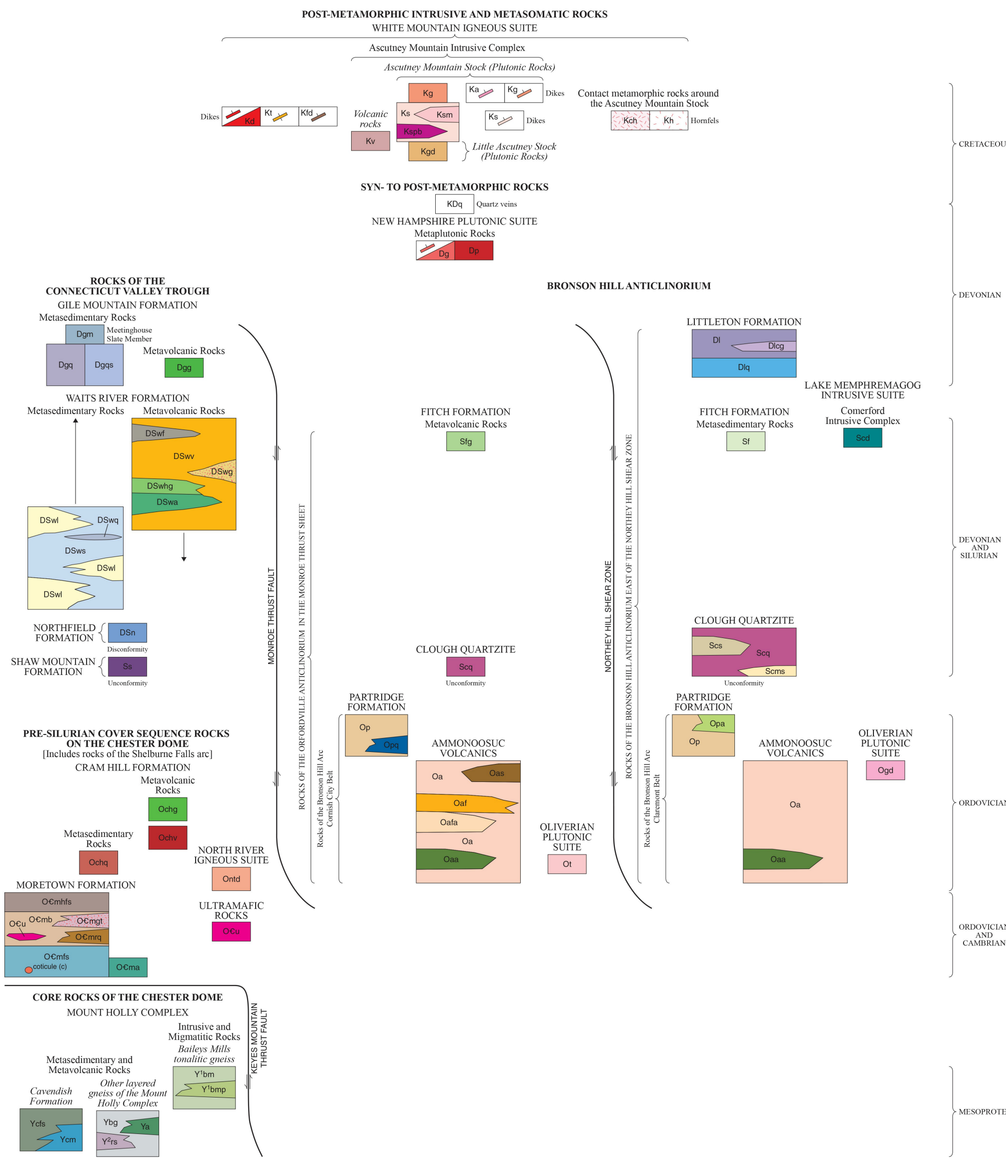
Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

The formal citation for this source.

Walsh, G.J., et.al., 2020, Bedrock geologic map of the Mount Ascutney 7.5- x 15-Minute Quadrangle, Windsor County, Vermont and Sullivan County, New Hampshire: U.S. Geological Survey, Scientific Investigations Map SIM-3440, scale 1:24,000 (*GRI Source Map ID 76318*).

Prominent graphics and text associated with this source.

Correlation of Map Units



Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Map Legend

Contacts, Outcrops, Faults, Folds, Minor Folds and Planar Features

[Taconic, Acadian, Neo-Acadian, and Alleghanian, refer to orogenic events and not to divisions of geologic time]

Contact—Approximately located; dotted where concealed by water; dashed where inferred in Corbin Park. In cross section, dotted where projected above the ground surface; projections are based on structural measurements of surface exposures

Outcrops—Areas of exposed bedrock or closely spaced contiguous bedrock exposures examined in this study; some areas are enlarged to show location

FAULTS

[Approximately located; dotted where concealed by water. In cross section, dotted where projected above the ground surface]

Pre-peak metamorphic thrust fault—Parallel to the Acadian S_1 foliation in the Connecticut Valley trough. The Keyes Mountain thrust fault may be Taconic. Sawteeth on upper plate

U D lower greenschist

Post-peak metamorphic strike-slip fault or shear zone (Alleghanian)—Steeply dipping, parallel to the S_2 or younger foliation; arrows indicate relative motion where known; U, upthrown side; D, downthrown side. Faults and shear zones are characterized by lower-greenschist facies metamorphic assemblages that overprint earlier higher-grade assemblages. Includes the Sumner Falls, Northey Hill, and Bald Mountain shear zones; location of Bald Mountain shear zone is inferred in Corbin Park

U D

Brittle fault (Mesozoic)—Steeply dipping; arrows indicate relative motion where known; U, upthrown side; D, downthrown side where known. Mz, Mesozoic

FOLDS

[Location is known or inferred; dotted where concealed by water. Symbols show trace of axial surface and direction of dip of limbs]

Axial trace of F_1 fold (Acadian, nappe-stage)

- Overturned anticline
- Overturned syncline

Axial trace of F_2 fold (Acadian or Alleghanian, early dome-stage)

- Overturned antiform
- Overturned synform

Axial trace of F_3 or younger fold (Alleghanian?)

- Antiform

MINOR FOLDS

Folds in the pre-Silurian rocks above and within the Chester dome

23 26

Strike and dip of inclined axial surface of minor isoclinal fold of schistosity or gneissosity that is parallel to the composite first and second generation schistosity (S_1-S_2); probably Taconic; arrow shows bearing and plunge of hinge line of fold. Minor folds are concentrated near and parallel to the fault between the core gneisses and pre-Silurian cover rocks of the Chester dome

41 15

Strike and dip of axial surface of minor fold that is parallel to nonpenetrative cleavage; arrow shows bearing and plunge of hinge line of fold. May correlate with F_2 and F_3 folds in the Silurian and Devonian rocks

57

Strike and dip of folded axial surface of F_1 fold that is parallel to S_1 foliation—Isoclinal, rootless folds; Acadian nappe-stage

Strike and dip of axial surface of F_2 fold that is parallel to S_2 foliation—Tight to isoclinal, locally rootless folds; Acadian early dome-stage

- 25 Inclined
- 62 Inclined, with horizontal fold axes
- Vertical

Strike and dip of axial surface of F_3 or younger minor fold—Open folds; Alleghanian late dome-stage or undifferentiated younger fold of undetermined age (possibly F_4 fold)

- 20 Inclined
- Vertical

Strike and dip of kink bands (S_4)—Mesozoic

- 34 Inclined
- Vertical

PLANAR FEATURES

[Symbols may be combined; point of intersection shows location of measurement]

Strike and dip of bedding

- 39 Inclined
- 15 Inclined, showing tops from graded beds or pillows
- 24 Inclined, overturned showing tops

Strike and dip of quartz vein (KDq)

- 42 Inclined
- Vertical
- Location only, no orientation measured

Strike and dip of mafic dike (Kd)

- 70 Inclined
- Vertical
- Location only, no orientation measured

Strike and dip of trachyte dike (Kt)

70 **Strike and dip of spherulitic felsic dike (Kfd)**

53 **Strike and dip of biotite-granite dike (Kg)**

Strike and dip of aplite dike (Ka)

- 55 Inclined
- Vertical

Strike and dip of syenite dike (Ks)

- 70 Inclined
- Vertical

68 **Strike and dip of granite dike (Dg)**

Location of pegmatite dike or sill (Dp)

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Foliation, Linear Features and Other Features

FOLIATION

Igneous flow foliation in the Ascutney Mountain Intrusive Complex

Inclined

Vertical

Planar features in the pre-Silurian rocks above and within the Chester dome

Strike and dip of inclined gneissic layering (gneissosity) of Proterozoic age; symbol inside the Ascutney Mountain Intrusive Complex indicates the location of small-scale Mesoproterozoic xenoliths in the Little Ascutney stock at Ascutney Notch

Generalized strike and dip of highly-plicated inclined schistosity of undetermined age

Strike and dip of inclined penetrative schistosity

Strike and dip of nonpenetrative spaced cleavage or crenulation cleavage; may correlate with S_2 or S_3 in Silurian and Devonian rocks

Planar features in rocks that are east of the Keyes Mountain thrust fault

Strike and dip of layer-parallel schistosity (S_1)—Parallel to bedding or compositional layering; Acadian

Inclined

Inclined, deformed

Vertical

Strike and dip of spaced foliation (S_2)—Variable across the map, less penetrative to the west, zonal in the east; Acadian to Alleghanian

Cleavage

Inclined

Vertical

Schistosity

Inclined

Vertical

Inclined, mylonitic or phyllonitic S_2 or S_3 foliation in local shear zones

Strike and dip of dominant foliation (S_n)—Not age specific, but either S_1 or a composite S_1-S_2 foliation expressed as a schistosity where S_2 is penetrative

Inclined

Vertical

Strike and dip of late crenulation cleavage (S_3 or S_4)—Associated with open folds and a crenulation lineation, which post-date the dominant schistosity; most apparent in fine-grained metapelites; Neo-Acadian, Alleghanian or younger

Inclined

Vertical

LINEAR FEATURES

[Symbols may be combined; point of intersection shows location of measurement]

Bearing and plunge of F_1 minor fold axis

Approximate bearing and plunge of folded F_1 minor fold axis

Bearing and plunge of L_2 intersection lineation—Intersection between the S_1 and S_2 foliations

Bearing and plunge of F_2 minor fold axis—Fold axis of tight, isoclinal, or rootless fold associated with S_2

Bearing and plunge of L_2 mineral lineation—Aggregate lineation or grain lineation associated with the S_2 foliation; consists of quartz, plagioclase, biotite, muscovite, chlorite, or amphibole

Bearing and plunge of L_2 rod or object lineation—Lineation composed of elongate objects such as pebbles and quartz or plagioclase phenocrysts; generally associated with the S_2 foliation but may represent an older L_1 lineation. The same symbol is used for the pre-Silurian rocks west of the Keyes Mountain thrust fault

Bearing and plunge of F_3 minor fold axis—Fold axis of late, open fold or crenulation lineation

Bearing and plunge of F_4 minor fold axis—Fold axis of late, open fold or crenulation lineation or kink band folds

OTHER FEATURES

Garnet / Biotite

Isograd or tectonic metamorphic boundary—Approximate boundary between rocks with biotite and (or) actinolite or locally chloritoid (in Scq) in the biotite zone; garnet and (or) hornblende in the garnet zone; staurolite in the staurolite zone; staurolite or kyanite in the Chester dome; and sillimanite-muscovite assemblages in the sillimanite zone of regional metamorphism; boundary is queried in Corbin Park where no data are available. Cordierite and biotite contact hornfels zones (Kch and Kh) are shown around the Ascutney Mountain stock; boundaries are uncertain in the Little Ascutney stock (Kgd) where the hornfels is difficult to recognize. The regional metamorphic boundaries locally coincide with (1) the Northey Hill or Bald Mountain shear zones, and (2) a splay of the Ammonoosuc fault that is east of Saint Gaudens National Historic Site

Abandoned quarry or mine—Four quarries (three named) are shown in the Ascutney Mountain stock and one zinc (Zn) resource mine is shown at the "Claremont Zinc Showing" that is labelled as "Zn" on the map in Claremont (source: Mineral Resources Data System, U.S. Geological Survey, 2018; identification number 10093852). The three named mines shown in the Mount Ascutney stock are (1) Norcross quarry, located in syenite (Ks) (Dale, 1909, 1923); (2) Mower quarry, located in syenite (Ks) (Dale, 1909, 1923); and (3) Enwrighte quarry, located in syenite (Ks) (Morrill and Chaffee, 1964; also spelled "Enright" by Perkins, 1908). Three closely spaced unnamed quarries, shown as one location on the map, on the south side of Mount Ascutney are also shown, located in granite (Kg) (Daly, 1903)

Spring

CN–3803 460±3 Ma

Geochronology sample location—Showing sample number and uranium-lead (U-Pb) zircon age in millions of years before present (Ma, mega annum) by sensitive high-resolution ion microprobe (SHRIMP), from Valley and others (2019; sample number CN–3803), Walsh and others (2014; sample number CN–3762), and McWilliams and others (2010; Sample 2, 418±7 Ma maximum depositional age (MDA) from detrital zircon)

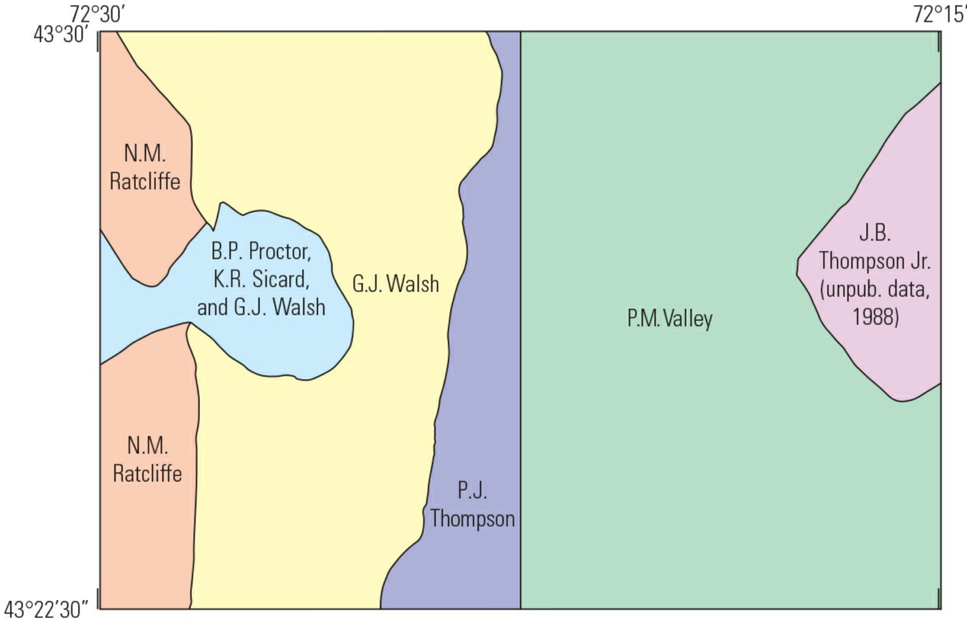
MA-510

Geochemical sample location—Showing sample number of whole-rock geochemistry analysis; results are given in table 1

Corbin Park boundary—Geology in Corbin Park on the geologic map and cross sections ***A–A′*** and ***B–B′*** is poorly constrained because access was denied for geologic mapping. Geology within the boundaries of Corbin Park is based on unpub. data from J.B. Thompson Jr., Harvard University (1988); all unit contacts are inferred. The boundary of the park is approximately mapped based on the ATV/snowmobile trails that follow the boundary along the outside of the perimeter fence

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

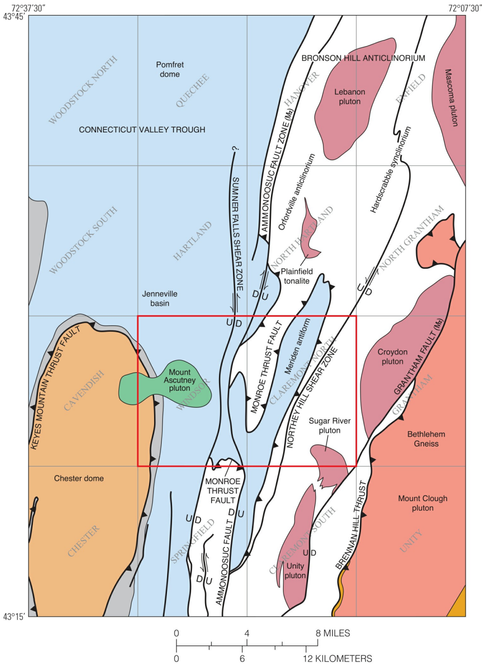
Geologic Mapping Index



INDEX TO GEOLOGIC MAPPING
[Colors do not correspond to map unit colors]

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Figure 1 (sheet 2) - Simplified Tectonic Map



EXPLANATION

- **White Mountain Igneous Suite (Cretaceous)**
- **New Hampshire Plutonic Suite (Devonian)**
- **Rangeley Formation (Silurian)**
- **Connecticut Valley trough (Devonian and Silurian)**
- **New Hampshire sequence (Devonian to Ordovician)**
- **Oliverian Plutonic Suite (Ordovician)**
- **Moretown and Cram Hill Formations and North River Intrusive Suite (Ordovician and Late Cambrian)**
- **Basement rocks (Mesoproterozoic)**
- **Contact**
- **Thrust fault**—Sawteeth on upper plate
- U D **Post-peak metamorphic fault**—Arrows indicate relative motion, queried where unknown; U, upthrown side; D, downthrown side. Abbreviation: Mz, Mesozoic

Figure 1. Simplified tectonic map and index to 7.5-minute quadrangles (outlined in gray). Modified from Ratcliffe and others (2011) and Lyons and others (1997). The area of this report is outlined in red.

Graphic from source map: [Mount Ascutney 7.5'x15' Quadrangle (Bedrock)]

Figure 2 (sheet 2) - Geochemical Results

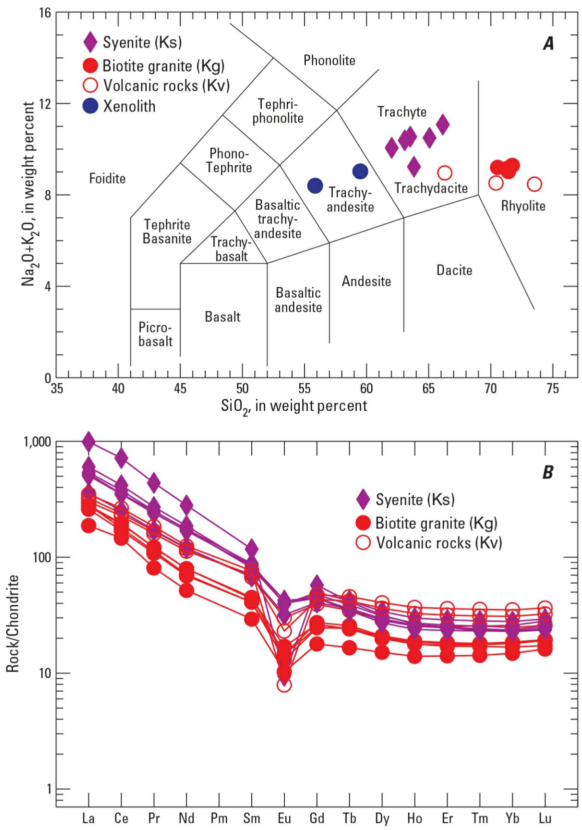


Figure 2. Diagrams showing the geochemical results for syenite (map unit Ks), biotite granite (map unit Kg), volcanic rocks (map unit Kv), and xenoliths from the Ascutney Mountain stock. ***A***, Geochemical results shown on a total alkali-silica (TAS) diagram (TAS diagram after LeBas and others, 1986). ***B***, Geochemical results shown on a rock/chondrite rare-earth element (REE) diagram (normalized REE diagram after Sun and McDonough, 1989). Foland and others (1985) report that the late-stage biotite granite was derived from basaltic magma by fractional crystallization with little or no crustal assimilation, whereas the more mafic magmas experienced greater crustal assimilation. The negative europium (Eu) anomalies (shown in ***B***) are consistent with magma sources having undergone fractional crystallization. Further, Foland and others (1985) describe the xenoliths as basaltic, but two analyses of "basic segregation" xenoliths within the biotite granite (Kg) plot as trachyandesite on the TAS diagram shown in ***A*** (xenolith data from Daly, 1903, p. 84). The sample locations (except for xenoliths) are included in the geographic information systems database. See Cox (1987) for the geochemical results for trace elements from rock, stream-sediment, soil, and panned concentrate samples for the entire Ascutney Mountain Intrusive Complex and the observation of a minor gold anomaly in gray sulfidic schist that is south and east of Mount Ascutney.

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Figure 3 (sheet 2) - Tectonic Map

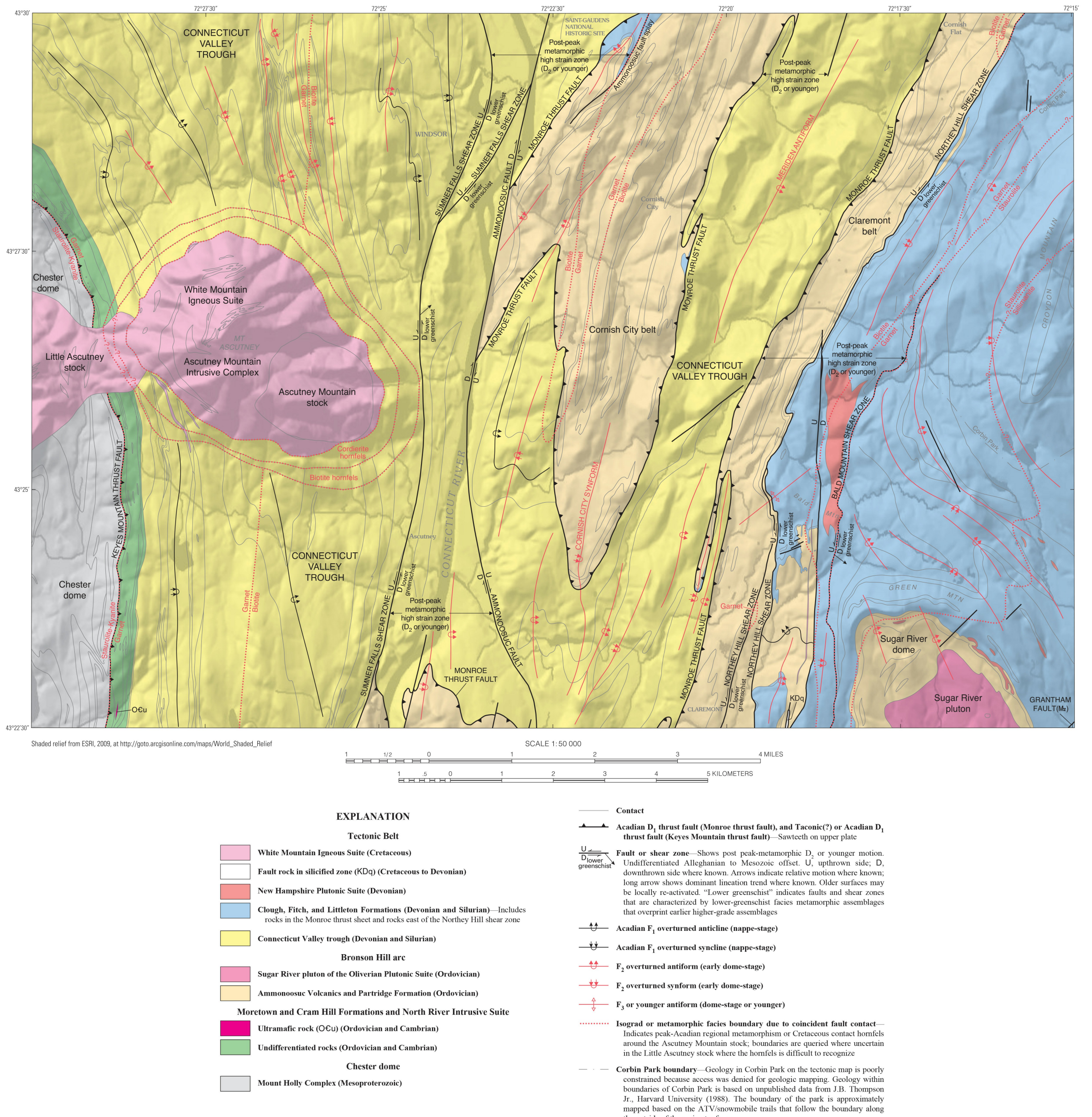


Figure 3. Tectonic map showing major structural features of the Mount Ascutney quadrangle. The axial traces of the F_2 folds (shown by solid red lines with arrows) define the dominant structural grain and deform Acadian F_1 folds and faults. Retrograde high-strain zones are recognized in the Connecticut River Valley, the Meriden antiform, and near the Northey Hill shear zone. These zones show evidence for both ductile and locally brittle deformation during protracted events. The Ascutney Mountain Intrusive Complex cross-cuts all Mesoproterozoic and Paleozoic structures.

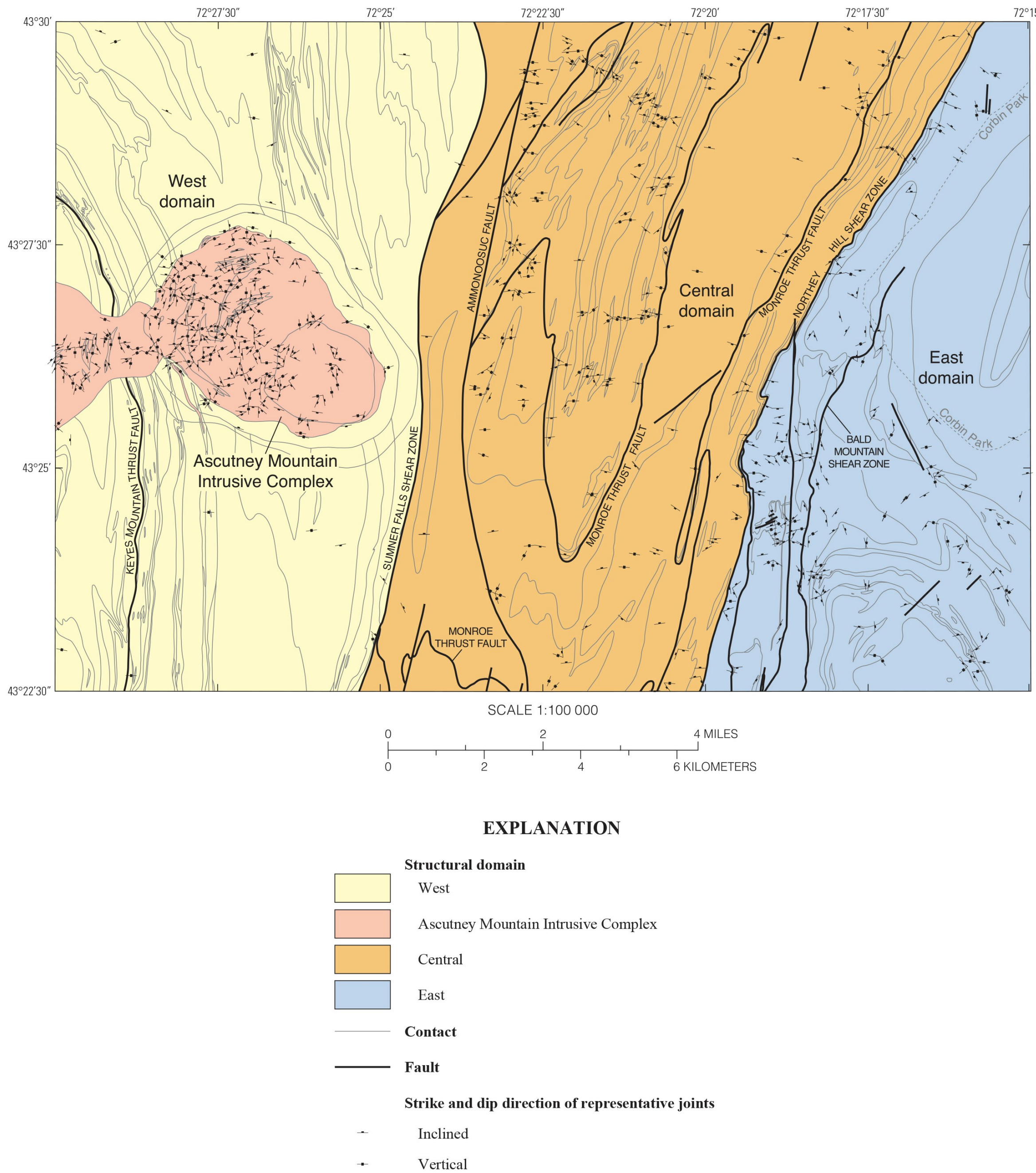
Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Figure 4 (sheet 2) - Structure Domain Maps and Stereonets

Structural domain map of the Mount Ascutney quadrangle showing the orientation and distribution of representative measured brittle features. Structural domain boundaries are divided by the Ascutney Mountain Intrusive Complex, the Sumner Falls shear zone (divides west and central domains), and the Northey Hill shear zone (divides central and east domains). The map shows the locations and data results for measured outcrop-scale joints, kink bands, brittle faults, and Cretaceous mafic dikes (map unit Kd). Results for measured joint data are summarized on four pairs of diagrams separated into four structural domains: the Ascutney Mountain Intrusive Complex and the west, central, and east domains. Each pair includes a stereonet and a rose diagram. Results for measured kink bands include all four structural domains shown on one stereonet and rose diagram (at top of map). Locations and data results for measured outcrop-scale brittle faults and Cretaceous mafic dikes (map unit Kd) are shown at top of map and also include all four structural domains. For all stereonets, contoured poles to the associated brittle features are shown along with the strike and dip orientations for poles to the principal planes in the dataset. For all rose diagrams a normalized subset of the data is shown in the corresponding stereonet for dips >59°, and principal peaks are shown with 1 standard deviation (for example, 276°±9° for the joints in the west domain). The number of data points is indicated by “n” at the bottom of each diagram. Stereonets and rose diagrams were plotted using the Structural Data Integrated System Analyser (DAISY, version 4.95.05) software by Salvini and others (1999) and Salvini (2013). Consult the GIS database for the complete data, which are not plotted on the figure due to cartographic constraints. Note that the outcrop-scale strike and dip symbols for joints and brittle faults are not shown on the geologic map. Also, the limited number of joint measurements in the west domain reflects limited fracture data collection in the previous study by Walsh and others (1996a, b) and does not indicate that the rocks are less jointed in the west domain. No structural measurements were taken in Corbin Park because access to the park was denied.

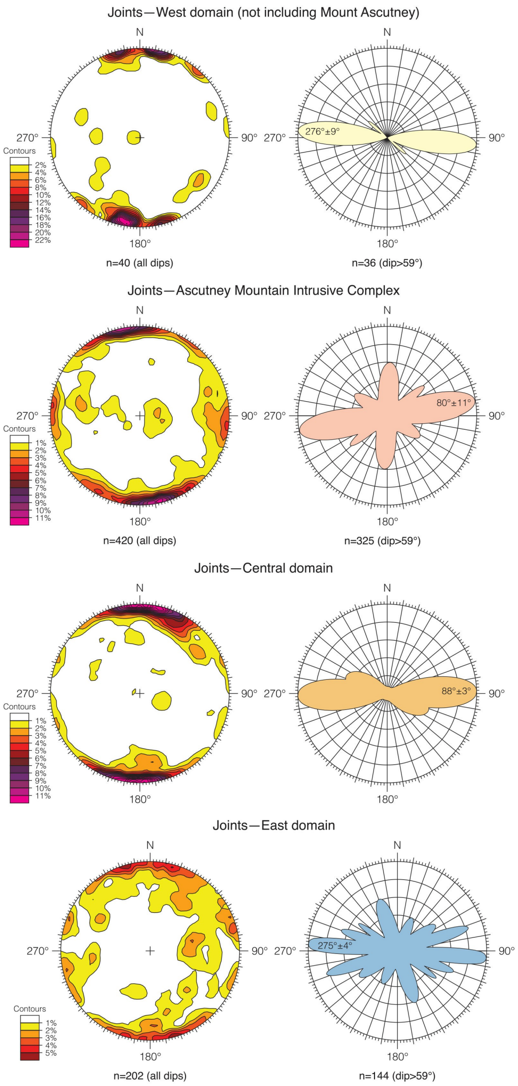
Figure text from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Figure 4 (sheet 2) - Domain Map



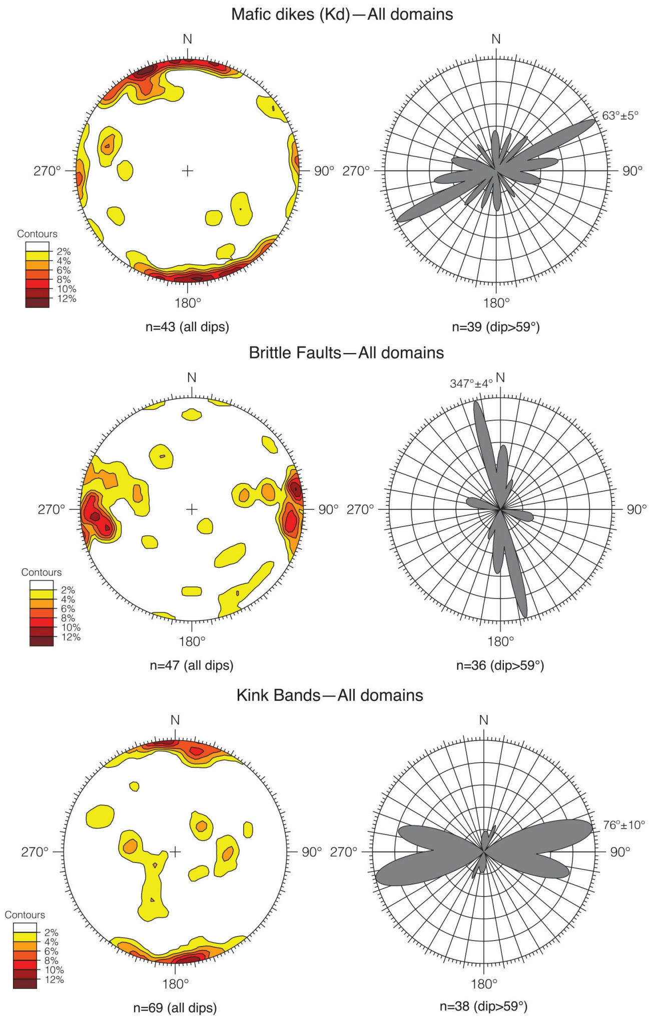
Graphic from source map: [Mount Ascutney 7.5'x15' Quadrangle (Bedrock)]

Figure 4 (sheet 2) - Joint Stereonets



Graphic from source map: [Mount Ascutney 7.5'x15' Quadrangle (Bedrock)]

Figure 4 (sheet 2) - Dike, Kink Band and Brittle Fault Stereonets



Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Photo 1 (sheet 2) - Photograph of Mount Acutney and the Cornish-Windsor Bridge

Photograph of Mount Ascutney and the Cornish-Windsor Covered Bridge from Cornish, New Hampshire, looking southwest across the Connecticut River towards Windsor, Vermont. Photograph by G.J. Walsh.

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Table 1 (sheet 2) - Whole Rock Geochemistry Results

Table 1. Whole-rock geochemistry results of map-unit rock samples from the Ascutney Mountain Intrusive Complex.

[Major elements are expressed as oxides. Whole-rock geochemistry by Actlabs, Acaster Ontario, Canada, using lithium metaborate/tetraborate fusion analysis by inductively coupled plasma (ICP) mass spectrometry (MS). Abbreviations: LOI, loss on ignition; MA, Mount Ascutney; ppm, parts per million]

	Map unit	Ks	Kv	Kg	Kg	Ks	Ks	Ks	Kg	Kg	Ks	Kg	Ks	Kv	Kv
	Sample number	MA-3030	MA-3033	MA-3042	MA-3048	MA-3084	MA-3117	MA-3162	MA-3169	MA-3175	MA-3193	MA-3219	MA-3251	MA-510	MA-511
	Description	Syenite	Volcanic rock	Biotite-granite	Biotite-granite	Syenite	Syenite	Syenite	Biotite-granite	Biotite-granite	Syenite	Biotite-granite	Syenite	Volcanic rock	Volcanic rock
Major element concentration, in weight percent	SiO_2	65.07	66.3	71.37	71.74	62.03	63.82	66.14	71.29	70.56	63.51	71.43	63.08	70.43	73.53
	Al_2O_3	15.93	15.41	13.84	13.95	16.48	15.36	15.98	14.05	14.82	16.37	13.69	16.62	13.9	13.11
	Fe_2O_3	4.24	3.87	2.41	2.22	5.38	5.14	3.1	2.35	2.86	4.24	2.32	4.47	2.78	1.93
	MnO	0.128	0.051	0.065	0.05	0.146	0.107	0.081	0.064	0.05	0.127	0.037	0.141	0.041	0.039
	MgO	0.78	0.46	0.39	0.36	1.25	1.33	0.15	0.38	0.41	0.74	0.33	0.77	0.28	0.31
	CaO	1.67	1.58	0.96	0.98	2.51	2.19	0.88	0.94	0.71	1.71	0.73	1.75	1.05	0.71
	Na_2O	4.91	4.72	4.43	4.5	4.88	4.58	5.13	4.48	4.48	4.92	4.32	4.81	3.56	3.65
	K_2O	5.59	4.24	4.69	4.79	5.18	4.65	5.95	4.67	4.72	5.63	4.7	5.58	4.96	4.82
	TiO_2	0.561	0.896	0.314	0.266	0.845	0.661	0.241	0.286	0.387	0.574	0.292	0.594	0.398	0.299
	P_2O_5	0.13	0.25	0.09	0.06	0.21	0.16	0.02	0.09	0.12	0.13	0.08	0.14	0.1	0.07
	LOI	0.45	0.43	0.65	0.61	0.26	0.57	0.37	0.14	0.61	0.25	0.33	0.32	0.49	0.27
	Total, in percent	99.47	98.19	99.20	99.54	99.17	98.57	98.05	98.72	99.73	98.19	98.25	98.28	97.99	98.73
Trace element concentration, in ppm	Sc	7	6	2	1	9	7	7	1	2	8	1	8	4	3
	Be	3	4	8	7	3	4	3	9	8	3	7	2	6	6
	V	17	45	15	13	38	38	<5	16	20	17	14	17	16	16
	Cr	<20	<20	<20	<20	20	40	<20	<20	<20	<20	<20	<20	<20	<20
	Co	4	5	3	2	7	8	<1	3	4	4	3	4	5	1
	Ni	<20	<20	<20	<20	20	20	<20	<20	<20	<20	<20	<20	<20	<20
	Cu	<10	<10	<10	<10	10	20	<10	<10	20	<10	<10	<10	<10	<10
	Zn	110	70	40	40	110	90	80	40	40	110	30	110	50	50
	Ga	27	28	27	26	27	27	29	26	27	28	26	27	28	31
	Ge	3.4	3.8	3	3.1	3.3	2.8	3.3	2.8	2.9	3	2.9	3.1	3.7	3.1
	As	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Rb	132	207	237	220	115	159	137	255	246	118	253	105	183	254
	Sr	122	262	193	183	202	162	11	204	238	141	184	132	168	73
	Y	44.5	38.3	31.8	29.4	40.1	39.5	36.3	28.9	26.9	34.4	22.2	37.1	48.3	56.2
	Zr	852	572	289	265	806	607	487	284	340	938	304	862	487	421
	Nb	102	123	158	145	110	113	87.9	147	155	83.9	151	85.2	149	159
	Mo	6	4	<2	<2	7	4	18	<2	3	3	4	4	<2	2
	Ag	1.4	0.9	<0.5	<0.5	1.2	0.8	0.7	<0.5	<0.5	1.3	<0.5	1.2	0.5	<0.5
	In	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Sn	5	2	7	8	4	7	5	7	7	5	7	4	5	3
	Sb	0.2	<0.2	0.4	<0.2	<0.2	0.3	<0.2	0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2
	Cs	1.6	5.2	3	1.5	1.3	2.6	1.5	3.3	3.7	1.8	2.8	1.9	4	2.8
	Ba	799	685	394	352	721	864	64	384	499	882	357	825	613	163
	La	124	76.9	65.1	61.5	120	84.8	235	66.9	66.2	143	44.4	128	71.5	82.8
	Ce	216	146	118	104	214	154	439	109	120	256	89.4	231	139	162
	Pr	23.6	16	11.6	10.3	22.7	16.2	41.6	10.7	11.5	25.8	7.69	23.8	15.2	17.5
	Nd	81.7	55.4	37.1	32.3	78.8	56	131	33.1	37.2	87.2	24.2	81.2	52.8	58.3
	Sm	13.5	10.3	6.88	6.26	12.9	10.4	18	6.26	6.7	13	4.48	12.4	10.8	11.7
	Eu	2.28	1.74	0.845	0.752	2.3	1.85	0.549	0.842	0.986	2.46	0.596	2.32	1.34	0.459
	Gd	10.2	8.08	5.62	5.07	9.77	8.36	11.8	5.09	5.42	9.13	3.67	9.15	8.9	9.76
	Tb	1.58	1.3	0.96	0.91	1.46	1.35	1.55	0.92	0.9	1.29	0.62	1.34	1.57	1.71
	Dy	8.66	7.28	5.32	5.22	7.89	7.47	8.01	5.19	5.04	6.92	3.84	7.25	9.24	10.3
	Ho	1.69	1.45	1.07	1.05	1.53	1.47	1.5	1.01	1.01	1.35	0.79	1.44	1.85	2.09
	Er	4.77	4.16	3.03	2.98	4.3	4.05	4.13	2.89	2.82	3.87	2.33	4.07	5.25	5.97
	Tm	0.721	0.652	0.46	0.455	0.649	0.615	0.615	0.449	0.434	0.59	0.363	0.596	0.793	0.905
	Yb	4.75	4.2	3.15	3.05	4.39	3.87	4	3.07	2.85	3.92	2.52	3.89	5.24	5.98
	Lu	0.746	0.658	0.493	0.489	0.715	0.6	0.651	0.488	0.44	0.623	0.41	0.61	0.824	0.927
	Hf	15.3	12.7	7.4	7.2	14.5	11.9	10.6	7.3	8	15.9	7.4	14.8	12.4	11.8
	Ta	6.28	8.62	13.3	12.8	7.54	7.55	5.06	13	12.9	5.34	12.9	4.92	10.5	11.9
	W	1.7	3.1	3.2	2.1	2	6.1	1.4	3.6	3.1	1.7	5.1	1.7	2.9	3.4
	Tl	0.29	0.43	0.38	0.32	0.22	0.27	0.28	0.4	0.43	0.23	0.41	0.21	0.43	0.56
	Pb	13	21	11	10	8	9	10	9	9	10	9	10	17	10
	Bi	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Th	12.9	17.6	33.4	33.1	12.8	15.9	26	37.8	31.5	15.5	34.7	12.4	20.3	26
	U	2.21	4.56	5.34	6.5	2.37	2.64	3.53	7.51	6.13	2.34	6.57	2.02	5.25	5.93

Graphic from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

Discussion

The bedrock geology was mapped to study the tectonic history of the area and to provide a framework for ongoing characterization of the bedrock of Vermont and New Hampshire. This Scientific Investigations Map of the Mount Ascutney 7.5- x 15-minute quadrangle consists of sheets 1 and 2 as well as an online geographic information system (GIS) database that includes contacts of bedrock geologic units, faults, outcrops, structural geologic information, and photographs. Sheet 1 of the report includes the bedrock geologic map. Sheet 2 includes a simplified tectonic map (fig. 1), and igneous rock geochemistry results (fig. 2; table 1) of the main map units from the Mount Ascutney stock. Sheet 2 also includes three cross sections from the geologic map on sheet 1, a tectonic map (fig. 3) showing major structural features, and a structural domain map (fig. 4) showing the orientation and distribution of measured joints, faults, and dikes with summary stereonets and rose diagrams. The report follows a preliminary report compiled for the Vennont part of the map area by Walsh and others (1996a, b).

The name "Mount Ascutney" has changed over the years on published topographic maps and in the geologic literature. Older published topographic maps listed the name as "Ascutney Mountain" and that name was applied in the classic scientific work by Daly (1903). Modern geographic usage lists the place name as "Mount Ascutney" and this report adopts that usage, except where the geologic nomenclature is well established, and there the term "Ascutney Mountain" is preserved.

SUMMARY OF BEDROCK GEOLOGY

The bedrock geology of the Mount Ascutney 7.5- x 15-minute quadrangle consists of highly deformed and metamorphosed Mesoproterozoic through Devonian metasedimentary and meta-igneous rocks intruded by rocks of the Mesozoic White Mountain Igneous Suite. In the west, Mesoproterozoic gneisses of the Mount Holly Complex are the oldest rocks and form the northeastern flank of the Chester dome (Ratcliffe and others, 2011). The allochthonous Cambrian through Ordovician rocks include the Moretown and Cram Hill Forniations and the North River Igneous Suite; these rocks structurally overlie the Chester dome along the Keyes Mountain thrust fault (Ratcliffe, 2000a, b; Ratcliffe and others, 2011), which may represent the ancient Ordovician suture (Red Indian line) between crustal blocks with Laurentian versus Ganderian affinity (Macdonald and others, 2014; Valley and others, 2019). Silurian and Devonian metasedimentary and metavolcanic rocks of the Connecticut Valley trough (CVT) unconfonnably overlie the pre-Silurian rocks. The easternmost extent of the CVT in New Hampshire is exposed in the Meriden antiform. Ordovician to Silurian and Devonian metasedimentary rocks of the Bronson Hill anticlinorium, sometimes referred to as the "New Hampshire sequence" (Billings, 1937, 1956; White and Jahns, 1950; Rankin and others, 2013), structurally overlie the CVT along the Monroe thrust fault. The oldest part of the Bronson Hill anticlinorium, called the Bronson Hill arc, consists of Ordovician metamorphosed volcanic, plutonic, and sedimentary rocks of the Ammonoosuc Volcanics, the Partridge Fonnation, and the Oliverian Plutonic Suite. The Ammonoosuc Volcanics represent the base of the exposed section in the area. The rocks of the Bronson Hill arc may be partly correlative with the pre-Silurian rocks above the Chester dome (Valley and others, 2019) and are exposed in two fault-bounded structural belts (Cornish City and Claremont belts) and in the Sugar River dome (fig. 2). Collectively, these belts form the regional Orfordville anticlinorium, Hardscrabble synclinorium, and the western part of the broader Bronson Hill anticlinorium in western New Hampshire (fig. 1). Silurian to Devonian metasedimentary rocks of the Clough Quartzite, and Fitch and Littleton Fonnations unconfonnably overlie the rocks of the Bronson Hill arc. Devonian granitic and pegmatitic dikes and sills of the New Hampshire Plutonic Suite intruded previously defonned rocks. Post-tectonic Cretaceous plutonic and volcanic rocks of the Ascutney Mountain Intrusive Complex (new fonnal name) underlie Mount Ascutney and Little Ascutney in the map area and in the adjacent Cavendish quadrangle (Ratcliffe, 1995a, 2000a). Informally referred to as the "Ascutney Mountain igneous complex" (Foland and others, 1985; Schneiderman, 1989, 1991; Ratcliffe and others, 2011), the name is formalized here as an intrusive complex in accordance with the North American Stratigraphic Code, article 37 (Easton and others, 2016, p. 220). The intrusive complex contains both intrusive and extrusive igneous rock types tliat are all lithodemic units within the White Mountain Igneous Suite (Ratcliffe and otl1ers, 2011). The complex only occurs in eastern Windsor County, Vennont, and tl1e type locality includes exposures on the peaks of Mount Ascutney and Little Ascutney. Hitchcock (1884) first used the name "Mount Ascutney granite" for rocks that only occurred at Mount Ascutney. Foyles and Richardson (1929) used the obsolete term "Mount Ascutney nordmarkite," which referred only to the syenite, and since the intrusive complex contains more than just granite and syenite these two names are obsolete. The Ascutney Mountain Intrusive Complex includes syenite, granite, aplite, gabbro, and diorite, with screens and xenoliths of co-magmatic volcanic rocks. Mount Ascutney is the classic location where Daly (1903) discussed the evidence for piecemeal stoping as a pluton emplacement mechanism. This theory was later modified to favor cauldron subsidence, or ring-fracture stoping, as an alternative mode of emplacement (Chapman and Chapman, 1940). Our new mapping supports the cauldron subsidence model, and shows that the main Ascutney Mountain stock is a funnel-shaped composite pluton in agreement with geophysical data (Daniels, 1990). Because of the historically significant scientific research, and its prominence in the landscape, Mount Ascutney is commonly regarded as Vermont's most famous volcano.

The oldest structure in the bedrock is a relict gneissosity in the Mesoproterozoic Mount Holly Complex in the Chester dome. At or near the contact with the pre-Silurian cover rocks, the Mesoproterozoic gneissosity was dragged into parallelism with a penetrative foliation that is a second-generation foliation in the pre-Silurian cover rocks. This second-generation foliation is axial planar to abundant isoclinal and reclined folds of botl1 the gneissosity in the Mount Holly Complex and tl1e schistosity in the overlying pre-Silurian rocks. This fabric is interpreted to be a relict Taconian foliation perhaps related to movement along the Keyes Mountain thrust fault. A younger and almost certainly Acadian foliation is also found subparallel to this older Taconian schistosity in the pre-Silurian rocks.

In contrast to the pre-Silurian rocks above the Chester dome, there is no clear evidence in the map area for an Ordovician deformational fabric in the exposed pre-Silurian rocks in the Bronson Hill arc; such evidence does exist in the older rocks beneath the Ammonoosuc Volcanics in the Albee Formation in the Littleton, New Hampshire area (Rankin and others, 2013). This implies that the Ammonoosuc Volcanics post-date regional deformation related to an orogenic episode interpreted as either Taconian or Penobscottian (Rankin and others, 2013).

The oldest foliation in the Silurian and Devonian rocks is a bed-parallel schistosity (Acadian S1) containing rarely observed isoclinal folds (Acadian F J These folds are the nappe-stage folds of Thompson and others (1968). Only in the hinge regions of these early F1 folds is it possible to see bedding that is not parallel to a foliation. Both the Connecticut Valley trough and Bronson Hill anticlinorium (BHA) rocks possess this first generation (Acadia.a S1) schistosity, but they do not appear to have developed under the same metamorphic conditions. The S1 foliation in the BHA appears to have developed prior to or during peak metamorphism that reached as high as staurolite grade (Walsh and others, 2012), but the S1 foliation in the western part of the CVT developed prior to the peak of upper greenschist facies metamorphism. In the western CVT, relative age relationships between porphyroblasts and fabric suggest that peak metamorphic conditions occurred during or after Acadian S2 development.

The second-generation planar fabric in all the Silurian and Devonian rocks (Acadia.a S) varies from a non-penetrative cleavage to a penetrative schistosity. Folds associated with the second-generation planar fabric (Acadia.a F) vary from open to isoclinal with generally consistent shallow plunges to both the north and south, but locally the plunges are quite steep. Acadian S1 and S2 are the most dominant, or visibly conspicuous, planar fabrics in the Silurian and Devonian rocks. Locally, tl1ese two planar fabrics are parallel, and it is difficult to discern one from the other. In such places where only a single penetrative schistosity is observed, and no crosscutting relative age relationships can be discerned, a foliation symbol is used to represent a dominant foliation (S) on the map. Acadia.a S and S2 are deformed by a minimum of two younger cleavages. The next youngest generation of planar fabrics include broad to open folds (F3) with both shallow and steep fold hinges and associated millimeter- to centimeter-spaced cleavage (SJ These structures have many different orientations, although they most commonly strike northeast, dip vertically to steeply northwest, and locally have sinistral rotation senses in the eastern part of the map. These structures are, in part, related to the last stages of doming, and the older Acadian S1 and S2 planar fabrics are deformed by them. It is not certain whether these younger "dome-related" structures are entirely coeval across the map. The S1 fabric is interpreted as Acadian, the S2 fabric is interpreted as Acadia.a to Neo-Acadian or even Alleghanian, and the S3 fabric is Alleghanian. Late-stage F 3 folds locally show preferred left-lateral rotation sense and are probably related to late dome-stage Alleghanian deformation or motion along lower greenschist-facies regional faults that were active at around 300 million years before present (Ma, mega-annum) (Mc Williams and others, 2013) or between 310 and 280 Ma (McAleer and others, 2017). The Bald Mountain shear zone shows that the re-activation of S2 fabric occurred during lower greenschist-facies metamorphism, with white mica recrystallization taking place as young as the Early Triassic where white mica yields 40 Ar/39 Ar ages of about 250 Ma (McAleer and otl1ers, 2016).

The youngest generation cleavage (S 4) in the area is a 1- to 30-cm-spaced cleavage that locally occurs as parallel sets of kink bands or low-amplitude, high-wavelength folds with variable fold hinge orientations. Secondary minerals, mainly quartz, calcite, and dolomite, occur as vein-filling material in the cleavage planes. This latest generation of cleavage generally strikes east-west and dips sub-vertically, sub-parallel to the regional joint trend (fig. 4). This cleavage, and the outcrop-scale and map-scale brittle faults in the area, may be related to Mesozoic extension (Hatch, 1988). In the Hartland and North Hartland quadrangles to the north, the kink bands are spatially related to the Almnonoosuc fault (Walsh, 2016), but sufficient data were not observed in this map area to demonstrate spatial correlation between kink bands and brittle faults. The youngest defonnation is characterized by Mesozoic brittle faulting, kink bands, motion along the Alnmonoosuc fault and smaller unnamed faults, possible re-activation of the Sumner Falls and Northey Hill shear zones, and subsequent jointing (figs. 3 and 4).

Rocks of the Mount Holly Complex in the core of the Chester dome may have reached hornblende-granulite-facies metamorphic conditions during the Mesoproterozoic Grenvillian orogenic events, and experienced subsequent metamorphism at lower grades during both the Ordovician (Taconic) and Devonian (Acadian) orogenic events. Peak metamorphic conditions in the Chester dome reached staurolite-kyanite grade during Paleozoic metamorphism, but direct evidence of Grenvillian granulite-facies metamorphism is lacking (Ratcliffe, 2000a, b). Paleozoic metamorphism locally attained amphibolite-facies conditions in the basement rocks, the pre-Silurian sequence, the eastern part of the BHA, and the western part of the CVT, but attained only greenschist-facies conditions in parts of the central CVT and BHA during the Acadia.a orogeny. We did not identify relict Taconian metamorphic mineral assemblages in the pre-Silurian rocks in this area, perhaps due to the thoroughness of recrystallization associated with the Acadia.a metamorphic overprint. The Monroe fault carried the BHA rocks over the CVT during an early Acadian F 1 nappe-stage event that pre-dated lower amphibolite-facies peak metamorphism. The onset of doming occurred during F2 defonnation, which folded the Monroe thrust sheet, folded earlier isograds, and created the Meriden antifonn and related structures. Doming continued as evidenced by the deformation of D2 by the D3 structures. Lower greenschist-facies (Alleghanian) faults such as the Sumner Falls and Northey Hill shear zones truncated peak-metamorphic assemblages, isograds, and older F1 folds and faults. These faults experienced a protracted history and played a major role in the metamorphic discontinuity documented along the Connecticut River Valley, evidenced by amphibole and muscovite 40Ar/39Ar ages of ~380 and ~330 Ma in Vennont, and ~330 and ~270 in New Hampshire (Harrison and others, 1989; McWilliams and otl1ers, 2013; McAleer and others, 2015). Additionally, in the vicinity of the Bald Mountain shear zone, 40Ar/39 Ar data from muscovite record a mixture of cooling ages of ~300 Ma and crystallization ages of ~245 Ma. The younger ages are associated with new muscovite and pseudomorphic replacement of staurolite, and the younger ages expand the occurrence of ductile deformation and down-to-the-east normal extension in the area into the Triassic (McAleer and others, 2014, 2015, 2016). These ages suggest that the peak metamorphic conditions developed during the Acadian orogeny and that retrograde greenschist-facies metamorphism occurred during the Alleghanian orogeny. Apatite fission-track data indicate that the Almnonoosuc fault was active prior to about 100 Ma and experienced little to no reactivation in the Cretaceous, but other regionally significant older ductile shear zones (such as the Northey Hill shear zone) experienced Late Cretaceous (approximately <80 Ma) reactivation (Roden-Tice and others, 2009). Recent data suggest some Cretaceous activity on regional brittle faults (for example, the Grantham fault in the Springfield quadrangle to the south) may have extended into the Paleocene (Schnalzer and others, 2015). The sense of displacement (shown on sheets 1 and 2) is identified where it was observed along faults, but given the protracted history (discussed above) the faults may be reactivated and may show varying senses of motion.

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Text from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

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Text from source map: Mount Ascutney 7.5'x15' Quadrangle (Bedrock)

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