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

Saint-Gaudens National Historic Site

GRI Ancillary Map Information Document

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

saga_geology.pdf

Version: 8/20/2015

Geologic Resources Inventory Ancillary Map Information Document for Saint-Gaudens National Historic Site

Table of Contents

Geologic Resources Inventory Map Document

Saint-Gaudens National Historic Site, New Hampshire and Vermont

Document to Accompany Digital Geologic-GIS Data

saga_geology.pdf

Version: 8/20/2015

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

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

For information about the status of GRI digital geologic-GIS data for a park contact:

Tim Connors
Geologist/GRI Mapping Contact
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2093
fax: (303) 987-6792
email: Tim_Connors@nps.gov

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

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
1201 Oak Ridge Drive, Suite 200
Fort Collins, CO 80525
phone: (970) 491-6655
fax: (970) 225-3597
e-mail: stephanie.omeara@colostate.edu

About the NPS Geologic Resources Inventory Program

Background

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

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

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

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

Products

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

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

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. 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: http://www.nature.nps.gov/geology/inventory, or contact:

Bruce Heise
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2017
fax: (303) 987-6792
email: Bruce_Heise@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Map and Source Map Citations

The GRI digital geologic-GIS map for Saint-Gaudens National Historic Site, New Hampshire and Vermont (SAGA):

Bedrock Geologic Map of Saint-Gaudens National Historic Site and Vicinity, New Hampshire and Vermont (*GRI MapCode SAGA*)

Walsh, Gregory J., Valley, Peter M., Thompson, Peter J., Ratcliffe, Nicholas M., Proctor, Brooks P., Sicard, Karri R. and Thompson, James B., 2015, Bedrock Geologic Map of the Mt. Ascutney 7.5 x 15 Minute Quadrangle, Windsor County, Vermont and Sullivan County, New Hampshire: U.S. Geological Survey, Scientific Investigation Map SIM-xxxx, scale 1:24000. (Mt. Ascutney 7.5 x 15 Minute Quad) (*GRI Source Map ID 76010).*

Walsh, Gregory J., 2015, 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 Investigation Map SIM-xxxx, scale 1:24000. (Hartland and N. Hartland Quads) (*GRI Source Map ID 76011).*

Both source maps "Prepared in cooperation with the State of Vermont, Vermont Agency of Natural Resources, Vermont Geological Survey, State of New Hampshire, Department of Environmental Services, New Hampshire Geological Survey, and the National Park Service".

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

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Saint-Gaudens National Historic Site, New Hampshire and Vermont (SAGA) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Kh - Hornfels around the Ascutney Mountain stock). Units are listed from youngest to oldest. No description for water provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (SAGAUNIT) table included with the GRI geology-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 - Ascutney Mountain stock, granite
Ksm - Ascutney Mountain stock, medium-grained syenite to quartz syenite
Ks - Ascutney Mountain stock, syenite
Kspb - Ascutney Mountain stock, plutonic breccia
Ka - Ascutney Mountain igneous complex, aplite dikes
Kv - Ascutney Mountain stock, trachyte to rhyolite and volcanic breccia
Kd - White Mountain Igneous Suite, mafic dikes
Kt - White Mountain Igneous Suite, trachyte dikes
Kfd - White Mountain Igneous Suite, spherulitic felsic dike
Kh - Hornfels around the Ascutney Mountain stock (outer zone)
Kch - Hornfels around the Ascutney Mountain stock (inner zone)
Kgd - Little Ascutney stock, gabbro and diorite

Mesozoic Era

MZsz - Silicified zone

Paleozoic to Mesozoic Eras

Devonian to Cretaceous Periods

KDq - Quartz veins

Paleozoic Era

Devonian Period

Dg - Granite
Dp - Pegmatite
Dl - Littleton Formation, gray quartz-laminated phyllite member
Dlc - Littleton Formation, Coticule and ironstone member
Dlcg - Littleton Formation, conglomerate member
Dlq - Littleton Formation, interbedded quartzite and schist member
Dgm - Gile Mountain Formation, Meetinghouse Slate 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
Dgqq - Gile Mountain Formation, quartzite, conglomerate, and metapelite member: quartzite to quartz pebble conglomerate
Dgqcm - Gile Mountain Formation, quartzite, conglomerate, and metapelite member: calcite marble clasts
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
Dgg - Gile Mountain Formation, greenstone member

Devonian and Silurian Periods

DSm - Polymict metaconglomerate member of unnamed melange
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
DSwl - Waits River Formation, limestone and schist member
DSws - Waits River Formation, gray phyllite and schist member
DSn - Northfield Formation, schist member
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

Silurian Period

Scd - Comerford Intrusive Complex, metadiabase dikes
Ss - Shaw Mountain Formation
Scs - Clough Quartzite, rusty muscovite schist member
Scms - Clough Quartzite, muscovite schist member
Scq - Clough Quartzite, conglomerate member

Ordovician Period
Oqd - Quartz diorite of the Lebanon dome
Op - Partidge Formation, sulfidic schist member
Opa - Partidge Formation, sulfidic schist member: amphibolite dikes
Opq - Partidge Formation, sulfidic schist member: quartzite
Opp - Partidge formation, plagioclase studded schist member
Oa - Ammonoosuc Volcanics, undifferentiated volcanic member
Oas - Ammonoosuc Volcanics, sulfidic schist member
Oaf - Ammonoosuc Volcanics, metafelsite member
Oafa - Ammonoosuc Volcanics, bimodal metavolcanic member
Oar - Ammonoosuc Volcanics, rusty sulfidic granofels member
Oal - Ammonoosuc Volcanics, lapilli tuff member
Oag - Ammonoosuc Volcanics, felsic granofels member
Oaa - Ammonoosuc Volcanics, amphibolite member

Ochg - Cram Hill Formation, greenstone member
Ochv - Cram Hill Formation, felsic and mafic volcaniclastic rock member
Ochq - Cram Hill Formation, quartzite member
Ontd - Trondhjemite gneiss
Ogd - Oliverian Plutonic Suite, granodiorite, trondhjemite and tonalite of the Sugar River pluton
Otp - Oliverian Plutonic Suite, Plainfield tonalite
Ot - Oliverian Plutonic Suite, unnamed tonalite

Cambrian to Ordovician Periods
Omhfs - Moretown Formation, hornblende fasicle schist member
Omb - Moretown Formation, black schist member
Omrq - Moretown Formation, quartzite
Omgt - Moretown Formation, garnet schist and granofels
Omfs - Moretown Formation, green schist and granofels member
Omfsc - Moretown Formation, coticule
Oma - Moretown Formation, amphibolite

Precambrian to Paleozoic Eras

Ordovician Period and Neoproterozoic Era?
OZu - Moretown Formation, talc-carbonate schist

Precambrian Era

Y1bm - Baileys Mills tonalitic gneiss of the Mount Holly Complex
Y1bmp - Mount Holly Complex, tonalite gneiss
Ycfs - Cavendish Formation, Feldspathic schist or granofel
Ycm - Cavendish Formation, marble
Ybg - Mount Holly Complex, biotite-quartz-plagioclase gneiss
Ya - Mount Holly Complex, amphibolite
Y2rs - Mount Holly Complex, rusty muscovite-biotite-plagioclase-quartz gneiss

Map Unit Descriptions

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

Kg - Ascutney Mountain stock, granite (Early Cretaceous)

Coarse-grained, locally medium-grained, largely homogeneous, biotite-quartz-microperthite-orthoclase-albite granite. 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 colored k-spar 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 (in GIS database) on the Mt. Ascutney State Park summit road, the contact can be seen as transitional across a 3-m-wide zone. Within this zone the granite was finer-grained and there were large (30 cm) pegmatitic zones with abundant quartz. These pegmatitic zones were 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 more mafic rich. 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, the granitic aplite dikes are curved and bifurcated, and 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 Mt. Ascutney and 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. Unit hosts the abandoned Daly quarry. (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Ksm - Ascutney Mountain stock, medium-grained syenite to quartz syenite (Early Cretaceous)

Medium-grained, light gray, white to very light-gray- to rusty-weathering, sericite-perthite-hornblende-biotite syenite to quartz syenite. Quartz content ranges from about 5-10 percent. The rock is characteristically finer grained than the surrounding host-rock syenite into which it intruded. The contact with the syenite (Ks) is typically sharp and some angular xenoliths of the coarse syenite were found within the medium-grained syenite. Locally contains volcanic xenoliths similar to the xenoliths within the syenite. Generally contains less mafic minerals than the coarse syenite but locally exhibits mafic-rich zones with euhedral hornblende crystals. Contains abundant, large (meter-scale) lenses of coarse syenite. Unit apparently intruded the coarse syenite via closely spaced dikes that interconnected and coalesced. Locally contains irregular, interfingering patches of coarse syenite. Mapped on the north side of Mt. Ascutney and well-exposed at the Ascutney North summit. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ks - Ascutney Mountain stock, syenite (Early Cretaceous)

Coarse-grained, locally porphyritic, light-gray, chalky white to very light-gray- to rusty-weathering, sericite-perthite-hornblende-biotite syenite. Contains accessory magnetite. Commonly contains xenoliths. Near the contact with the country rock (within ~400m or less), large meter-scale and smaller xenoliths of the hornfels are common. Past the ~400m boundary, 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. The xenoliths are commonly softball sized or smaller and angular to sub-rounded in shape. Areas with a very high density of xenoliths (up to 70 or 80% 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 Mt. Ascutney. Dikes of syenite in the Little Ascutney gabbro and diorite (Kgd) stock contain xenoliths of the Mount Holly Complex gneiss. Occurs as the main stock of Mt. Ascutney and 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. Unit hosts three abandoned quarries (Mower, Enwrighte, Norcross). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kspb - Ascutney Mountain stock, plutonic breccia (Early Cretaceous)

Same lithological description as unit Ks (above) but is mapped separately as plutonic breccia (Kspb) in areas with a very high density of xenoliths (up to 70 or 80% of the rock), most notably at Cascade Falls. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ka - Ascutney Mountain igneous complex, aplite dikes (Early Cretaceous)

Very fine-grained, light tan or pink, undifferentiated syenite to granite aplite dikes. Thirty outcrop-scale dikes are shown by strike and dip symbols, and range from centimeters up to 5.0 m thick. The dikes occur on Mt. Ascutney and intrude the syenite (Ks), the granite (Kg), the gabbro-diorite (Kgd) and the hornfels (Kch). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kv - Ascutney Mountain stock, trachyte to rhyolite and volcanic breccia (Early Cretaceous)

Undifferentiated, fine-grained, gray to purple trachyte and rhyolite tuff and volcanic breccia containing fragments of volcanic rocks having trachytic flow structure and layering. Interpreted as volcanic rocks of the edifice. Well-exposed west of the Mt. Ascutney summit on the hiking trail (Weathersfield Trail, name not on map) and upstream of Crystal Cascade Falls. Schneiderman (1989) and Chapman and Chapman (1940) describe the volcanic units at Mt. Ascutney in greater detail. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kd - White Mountain Igneous Suite, mafic dikes (Cretaceous)

Kd - White Mountain Igneous Suite, mafic dikes (Cretaceous)
Aphanitic, dark-gray to black, locally rusty weathering, lamprophyre, camptonite, or diabasic dikes. Forty-six dikes are shown by point symbols, and range from centimeters up to 2.0 m thick. May contain phenocrysts of biotite, amphibole, pyroxene, and olivine. May contain amygdules filled with dolomite or calcite. Generally, dikes intrude parallel to steeply dipping joint sets and show variable orientations with a calculated principal trend of 63° ± 5°. Dikes are unfoliated but may be blocky jointed. One 3-m-thick dike was traced discontinuously for over 8 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 mapped dikes is exaggerated to show location. Many dikes cut the syenite at Mt. Ascutney, so these undated dikes are younger than about 122 Ma. (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Kd - White Mountain Igneous Suite, mafic dikes (Cretaceous)
Aphanitic, dark-gray to black, undifferentiated lamprophyre, camptonite, or diabasic dikes. Dikes range in thickness from 0.1 to 2.5 m and may contain phenocrysts of biotite, amphibole, pyroxene, and olivine.

May 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, dikes intrude parallel to joint sets. Dikes are unfoliated but may be blocky jointed. Shown as polygonal map units or with strike and dip symbols; thickness of map units is exaggerated to show location. (*GRI Source Map ID 76011*) (Hartland and N. Hartland Quads).

Kt - White Mountain Igneous Suite, trachyte dikes (Cretaceous)

Kt - White Mountain Igneous Suite, trachyte dikes (Cretaceous)
Aphanitic, gray to light-gray, tan-weathering, trachytic dikes. Dikes range in thickness from 0.7 to 1.5 m. Dikes are unfoliated but may be blocky jointed. Three dikes occur on the west side of Mount Ascutney and intrude the syenite (Ks), the hornfels (Kch), and the mafic volcanic rocks in the Waits River Formation (DSwa and DSwhg). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kt - White Mountain Igneous Suite, 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 joint sets. Dikes are unfoliated but may be blocky jointed. Shown with strike and dip symbols only. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Kfd - White Mountain Igneous Suite, spherulitic felsic dike (Cretaceous)

Tan to light-gray, dark-gray to rusty-weathering, very fine-grained, discontinuously laminated, spherulitic felsic dike. Flow laminations are 1 to 2 mm thick and parallel to the walls of the dike. 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 echelon dikes, 20 to 40 cm thick, at an exposure in Mill Brook 1.1 km west of the junction of 1-91 and Route 131 in the Mount Ascutney quadrangle. The dikes are parallel to an east-west striking and steeply north dipping joint set (strike 257°, dip 70°). Balk and Krieger (1936) describe other felsic dikes with similar divitrification features in the vicinity of Mount Ascutney. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kch & Kh - Hornfels around the Ascutney Mountain stock (Cretaceous)

Layered, dark and light colored, foliated, hornfels. The hornfels is subdivided into outer (Kh) and inner (Kch) zones based on a textural change from black to dark-gray, laminated, flinty hornfels ± biotite (Kh) to a more indurated, variably light and dark colored layered black to dark-gray or purple to purplish gray and light-gray to pale bluish-green and light-pink cordierite hornfels (Kch). The outer contact between the hornfels (Kh) and the rocks of the Waits River Formation is transitional; the contact is drawn on a textural basis and is located approximately where the phyllitic and schistose character of the country rock loses its fissility and becomes flinty, but the protolith is still recognizable. The hornfels becomes progressively indurated towards the intrusion. 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, wollastonite, and locally 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 sub-vertical to steeply dipping inward towards the core of the pluton. Daly (1903), Nielson (1973), and Schneiderman (1989) describe the hornfels in detail. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Kgd - Little Ascutney stock, gabbro and diorite (Early Cretaceous)

Undifferentiated, coarse-grained, dark-green hornblende biotite gabbro and lighter colored cross-cutting medium- to coarse-grained, in places porphyritic, biotite-hornblende diorite. Foland and Faul (1977) and Foland and others (1985) dated the gabbro-diorite complex at 125.5 - 122.2 Ma by K-Ar on biotite. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

MZsz - 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 – 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

KDq - Quartz veins (Devonian to Cretaceous)

KDq - Quartz veins (Cretaceous to Devonian)
White to gray weathering quartz veins. Veins range in size from 0.1 to 3 m. May locally contain small amounts of muscovite, chlorite, graphite, sulfides, and carbonate minerals. Shown as polygonal map units or with strike and dip or point symbols; thickness of map units is exaggerated to show location. A 10 m thick vein exposed near the southern border of the map east of Claremont may be a Mesozoic silicified zone related to brittle faulting. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

KDq - Quartz veins (Devonian and Cretaceous)
White quartz veins. May locally contain small amounts of muscovite, chlorite, graphite, sulfides, and carbonate minerals. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

DSm - Polymict metaconglomerate member of unnamed melange (Devonian and Silurian?)

Mélange, Polymict metaconglomerate member (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. Contains clasts of gray, black, and tan quartzite, pebbly quartzite, vein quartz, black schist, metavolcanic rocks, and rare granitoid suggesting that rock is derived from the pre-Silurian rocks in the Bronson Hill anticlinorium. Some clasts have a metamorphic fabric which implies a pre-deformed source. Contains gray, calcareous graphite-chlorite-calcite-muscovite-biotite-quartz granofels with small vugs at one place at French's

Ledges; this rock resembles the Fitch Formation unit Sfgr. The matrix may be re-worked 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 mélange, 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 mélange contains clasts of the Clough Quartzite indicating that its formation post-dates deposition of the Clough (Thompson and others, 2012). The mélange is spatially related to the Monroe thrust, supporting a tectonic origin for this belt of rock (Thompson and others, 2012). The mélange is exposed on either side of Route 120 near the junction of Whitaker Road and south of the junction with Underhill Road. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Dg - New Hampshire Plutonic Suite, granite (Devonian)

Massive to moderately well-foliated, ±garnet ±microcline-muscovite-biotite-quartz-plagioclase granite to trondhjemite dikes and sills. Cross cuts foliated country rocks. The dikes cut an early bed-parallel foliation (S1) in the Silurian Devonian rocks, and either pre-date or are synchronous with the development of the S2 foliation. May be shown by strike and dip symbol only. The stock at Bald Mountain intrudes the Littleton Formation and yields a U-Pb 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). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Dp - New Hampshire Plutonic Suite, pegmatite (Devonian)

White to pink weathering, massive, tourmaline-biotite-muscovite-quartz-k-feldspar ± garnet pegmatite. Pegmatite layers are largely concordant with the dominant foliation and layering, but locally crosscut the rocks they intrude. Mapped pegmatite is restricted to the southeastern part of the map where they are deformed by the D2 deformation fabric in these rocks. Shown as polygonal map units or with strike and dip or point symbols; thickness of map units may be exaggerated to show location. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Dl - Littleton Formation, gray quartz-laminated phyllite member (Lower Devonian)

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 rusty weathering, and in such places it is extremely difficult to distinguish this unit from the Partridge Formation. Contains characteristic garnet and large cm-scale staurolite at higher metamorphic grades. Garnet is locally 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. 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 and Fitch 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. (*GRI Source Map ID 76010)* (Mt. Ascutney

7.5 x 15 Minute Quad).

Dl - Littleton Formation, gray quartz-laminated phyllite member (Lower Devonian)
Dark- 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Dark- to light silvery gray, lustrous, locally thinly laminated, carbonaceous chlorite±biotite-plagioclase-quartz-muscovite schist and phyllite and thin quartzite with distinctive, thin (1 - 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. Crops out at the base of the Littleton Formation in the Prospect Hill belt . (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Dlcg - Littleton Formation, conglomerate member (Lower Devonian)

Gray to very light-gray, white chalky weathering, fine-to coarse-grained, quartz pebble conglomerate and polymict conglomerate. Conglomerate varies from clast-supported conglomeratic layers up to 30-cm-thick to isolated, matrix-supported pebbles. May contain felsic volcanic clasts or volcaniclastic rock. Occurs within the Dl member < 200 m above the contact between Dl and Scq, southwest of Bald Mountain. Thickness of the unit is variable from 1 to 5 m and the thickness is exaggerated on the map to show its location. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Silvery gray to dark-gray, micaceous quartzite, interbedded micaceous quartzite with biotite-muscovite-quartz schist, and carbonaceous schist. Quartzite layers are distinctly “sandy” or rough to the touch. Contains characteristic garnet and large cm-scale staurolite at higher metamorphic grades. Garnet is locally 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 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 largely 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 is in places interfingered with Dl. Typical exposures occur along the power line southwest of Chapin Pond and along Cat Hole Road north of Green Mountain . (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

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 synto 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 due to deformation induced recrystallization. Unit is exposed on the east side of the Meriden antiform. Lower contact is gradational with Dgq and the upper contact is the Monroe thrust. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Dgm - Gile Mountain Formation, Meetinghouse Slate Member (Lower Devonian)
Gile Mountain Formation (Lower Devonian) Metasedimentary Rocks Meetinghouse Slate Member – 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 1-5 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. Unit is well exposed at the North Hartland Dam spillway. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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 slightly calcareous rock 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 2-100 cm. In the core of the Meriden antiform Dgq consists largely of quartzite, locally with 10 percent or less of metapelite. Layering becomes “pinstriped” near the Monroe thrust. The lower contact is gradational with the Waits River Formation and the upper contact is either a facies change where in contact with upper members of the Gile Mountain Formation or tectonic where in contact with the Ammonoosuc Volcanics and Partridge Formation. Unit is well-exposed in Cornish on Kenyon Hill, Parsonage Hill, and Spaulding Hill. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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 slightly calcareous rock 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 2-100 cm. In the core of the Meriden antiform Dgq consists largely of quartzite, locally with 10 percent or less of metapelite. Unit is well-exposed in Cornish and Plainfield on Fernald Hill, Yetsevitch Hill, Stevens Hill, and on the lower western slopes of Home Hill. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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. Quartzite is generally less than 50 percent of the unit. Locally sulfidic. Unit is similar to the phyllite and schist member (DSws) of the Waits River Formation, but generally has more quartzite beds. Unit is also similar to Dgq but has fewer quartzite beds. Typical exposures occur in Windsor on Horseback Ridge and in Claremont on Twistback Hill. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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. Locally sulfidic. Unit 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 . (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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 1040 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Same lithological description as unit Dgqc (above) but is a white quartzite to quartz-pebble conglomerate only observed and mapped at a single outcrop on the west side of Penniman Hill at an elevation of 1040 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Same lithology description as unit Dgqc. East of Whitaker Road the rock contains clasts of white and gray calcite marble, and there it is mapped as unit Dgqcm. (*GRI Source Map ID 76011)* (Hartland and N.

Hartland Quads).

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. Unit interpreted as a volcaniclastic rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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. Unit resembles DSwf. Crops out on Blake Hill in the northwestern corner of the map. Unit interpreted as a mixed volcaniclastic and sedimentary rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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 1100 feet. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Dgg - Gile Mountain Formation, greenstone member (Lower Devonian)
Green to greenish-black, massive to schistose, fine- to medium-grained, ±carbonate-epidote-actinolite-plagioclase-chlorite greenstone and silvery gray-green ankerite-plagioclase-chlorite-quartz schist. 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. Poorly exposed in an unnamed stream on the north side of Dingleton Hill. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Dgg - Gile Mountain Formation, greenstone member (Lower Devonian)
Layered to massive, dark-green to green, fine-grained ±actinolite-epidote-chlorite-plagioclase greenstone; contains accessory biotite, opaques, and calcite. Locally sulfidic. The western map unit on Fernald, Yatsevitch, and Smith Hills is generally fine-grained and layered, locally contains large (as much as 30 cm) epidote boudins, and is intercalated with silvery gray-green chlorite-muscovite-quartz-plagioclase schist along the contacts with the adjacent feldspathic quartzite, granofels, and metapelite member (Dgq). This western belt is interpreted as a mafic volcanic to volcaniclastic rock. The eastern unit on Penniman Hill is massive, it exhibits diabasic texture with amphibole-actinolite intergrowths, and the contacts with Dgq are sharp; this unit may be a massive flow or a dike. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Heterogenous, laminated (mm-scale) to layered (cm-scale), green and white, in places rusty-weathering, fine to medium-grained, muscovite± biotite-chlorite-quartz-plagioclase schist; silvery-green, fine- to medium grained, muscovite± biotite-chlorite-quartz-plagioclase schist; gray-green, medium grained, muscovite± biotite-chlorite-quartz-plagioclase granofels; gray to light gray, biotite-chlorite-muscovite-quartz-plagioclase± carbonate ±garnet granofels in 5-cm to 2-m-thick beds with coarse (1- to 8-mm-diameter) plagioclase and quartz porphyroclasts; green, fine-grained, quartz-epidote-chlorite-plagioclase schist or greenstone; and silvery-gray, rusty- weathering calcite-muscovite-chlorite-quartz plagioclase schist. In places, the unit is pitted where it contains accessory carbonate; contains accessory ilmenite porphyroblasts and porphyroclasts 1 to 5 mm in diameter. Unit is interpreted as a heterogenous assemblage of metamorphosed volcaniclastic and primary volcanic rocks. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Light-gray, tan-weathering, biotite-quartz plagioclase gneiss, and medium-gray, feldspathic biotite quartzite and granofels, and volcaniclastic rock interbedded with DSwhg. Unit limited to the northwest part of the map near Sheddsville. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Gray-green to light-gray, medium-grained hornblende-muscovite-quartz-plagioclase-chlorite-biotite schist with quartz and plagioclase phenocrysts up to 1 cm long; contains accessory calcite, ilmenite, apatite, and idocrase. Unit is interpreted as a primary volcanic rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

DSwg - Waits River Formation, large garnet and hornblende garbenschiefer schist member (Lower Devonian and Upper 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. Unit is interpreted as metamorphosed pelitic sedimentary rock with a volcaniclastic component of intermediate to mafic composition. Unit is interlayered with DSws and DSwl, and all volcanic units. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

DSwg - 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. Unit is interpreted as metamorphosed pelitic sediments with a volcaniclastic component.

(*GRI Source Map ID 76011*) (Hartland and N. Hartland Quads).

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

DSwhg - Waits River Formation, hornblende-plagioclase gneiss member (Lower Devonian and Upper Silurian)
Dark-green, medium- to coarse-grained, epidote chlorite± garnet-hornblende-plagioclase gneiss with roughly equal percentages of hornblende and plagioclase. Unit varies from a massive, weakly foliated, and very coarse-grained gneiss to a well layered gneiss. Where massive, intergrowths of hornblende with matrix plagioclase are ubiquitous, forming a possible replacement for relict ophitic texture. Exposures north of Hunt Road in Windsor are of the well-layered variety. Contacts with surrounding units are sharp. The massive variety may, in part, be intrusive. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

DSwhg - Waits River Formation, hornblende-plagioclase gneiss member (Lower Devonian and Upper Silurian)
Medium- 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. Unit interpreted as a mafic volcanic flow or composite flow. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Dark-green to green, fine-grained, massive epidote chlorite-hornblende-plagioclase gneiss (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 north central 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 there it contains layers of greenstone similar to those found to the east. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Silvery, rusty yellow weathering, sulfidic quartz-muscovite schist. Unit interpreted as a hydrothermally produced stratiform sulfide deposit. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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. 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 as much as 10 to 90 percent of an exposure; bedding in the metapelite is generally not visible. Contacts with adjacent units are gradational to sharp as limestone beds either decrease in abundance and thickness gradually or abruptly. Contacts with DSws are interpreted as facies changes and may not necessarily imply stratigraphic order. Unit is well-exposed on Interstate 91. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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. Unit is well-exposed on Interstate 91 and in Lulls Brook south of the village of Hartland. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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, fine-grained, lustrous, carbonaceous chlorite-muscovite-plagioclase-quartz schist and phyllite. In places interbedded with thin, gray quartzite, tan to gray feldspathic quartzite, and gritty plagioclase-quartz granofels. Beds range in thickness from 3 to 10 cm. Locally contains trace amounts of very thin (1-2 cm) brown-weathering limestone beds. The schist contains biotite and garnet in the western part of the map. Unit is similar to, but generally has fewer quartzite layers than, Dgqs. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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. Contains trace limestone. Unit 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Dark-gray to silvery gray, carbonaceous, fine-grained, 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. Garnets are commonly partially to completed replaced by white plagioclase or by chlorite. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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 Sfgr at the railroad cut in Hartford, west of Johnston Island. 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

> *Note: While the currently accepted age of the Fitch Formation is Upper Silurian, source map data used for this dataset reflects recent research involving fossil data dating to earliest Devonian found with the Fitch Formation.*

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 much as a few cm) calcite-filled vugs and weathered pits. Contains as much as a few percent sphene, apatite, epidote, and opaques. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

> *Note: While the currently accepted age of the Fitch Formation is Upper Silurian, source map data used for this dataset reflects recent research involving fossil data dating to earliest Devonian found with the Fitch Formation.*

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 (cm-scale) layers and boudins of magnetite-garnet-quartz coticule. Interlayered with the greenstone member (Sfgg) along its lower contact. Occurs on the eastern side of Read Hill above the greenstone member (Sfgg) and below the marble member (Sfm) or Littleton Formation (Dl). (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

> *Note: While the currently accepted age of the Fitch Formation is Upper Silurian, source map data used for this dataset reflects recent research involving fossil data dating to earliest Devonian found with the Fitch Formation.*

Sfg - 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 ±ilmenite±apatite±calcite±actinolite±biotite-quartz-chlorite-epidote-hornblende plagioclase greenstone and laminated chlorite schist. Unit exposed on the north slopes of Dingleton Hill where it extends into the adjacent North Hartland quadrangle (Walsh, in press). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Sfg - Fitch Formation, greenstone member (Lower Devonian and Upper Silurian)
Massive to layered, green to gray-green, fine-grained ±ilmenite±apatite±calcite±actinolite±biotite-quartz-chlorite-epidote-hornblende plagioclase amphibolite or greenstone. Unit exposed in Plainfield from Mill Village to southwest of Bartlett Four Corners; typical exposures occur in Blow-Me-Down Brook upstream of Mill Village. Occurs above the Clough Quartzite at the base of the Fitch Formation. Contains deformed pillows exposed in Blow-Me-Down Brook. Unit interpreted as mafic volcanic and volcaniclastic rock; perhaps the eruptive correlatives to the dikes of the Comerford Intrusive Complex (Scd). (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

> *Note: While the currently accepted age of the Fitch Formation is Upper Silurian, source map data used for this dataset reflects recent research involving fossil data dating to earliest Devonian found with the Fitch Formation.*

Sf - Fitch Formation, gray granofels and schist member (Lower Devonian and Upper Silurian)

Gray to dark greenish-gray, medium-grained, actinolite/tremolite-muscovite-biotite-carbonate-quartz ± magnetite granofels and schist. Locally contains distinctive irregular dissolution cracks and holes, locally along bedding. Contains calc-silicate pods comprised of garnet, quartz, actinolite, and diopside. Contains variably rusty to bronze-weathering, medium-grained carbonate-biotite-quartz schist with carbonate pods and layers 2 cm to 10 cm thick. Also contains gray to light-gray, medium-grained, biotite-chlorite-garnet-muscovite-quartz schist and micaceous quartzite with distinctive high-relief weathering quartz-rich knots, pods, layers or pebbles; pods are comprised predominantly of quartz but contain garnet, magnetite, biotite, and muscovite. Disseminated magnetite is common in all rock types. Millimeter to cm scale magnetite layers are present locally near the contact with the Littleton Formation and Clough Quartzite. Best exposed between Ram Brook and Brighton Road and just west of the Cornish Turnpike along the Cornish-Claremont town line. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

> *Note: While the currently accepted age of the Fitch Formation is Upper Silurian, source map data used for this dataset reflects recent research involving fossil data dating to earliest Devonian found with the Fitch Formation.*

Scd - Comerford Intrusive Complex, metadiabase dikes (Silurian)

Scd - Comerford Intrusive Complex, metadiabase dike (Silurian)
Massive, medium-grained, very dark green to black and white, calcite-epidote±garnet-chlorite-biotite-hornblende-plagioclase amphibolite. Shown by one map unit found within the Clough Quartzite, exposed on a jeep trail on Green Mountain; contacts with surrounding quartzite are not exposed. Alternatively, the amphibolite could be a volcanic layer and not a dike. Correlated with the Comerford Intrusive Complex dated at 419 ± 1 Ma (Rankin and others, 2007). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Scd - Comerford Intrusive Complex, metadiabase dikes (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. Contains leucocratic black and white segregations of hornblende-plagioclase pegmatitic diorite with intergrown phenocrysts up to 2 cm across. Dikes post-date compositional layering within the Ammonoosuc Volcanics and measure as much as several-m-thick. Shown by map units and as strike and dip symbols. Map units consist of swarms of dikes in the host Ammonoosuc Volcanics. Correlated with the Comerford Intrusive Complex dated at 419 ± 1 Ma (Rankin and others, 2007). 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Ss - Shaw Mountain Formation (Silurian)

Heterogeneous unit of interbedded rusty, slabby quartz-amphibolite, gray quartzite, feldspathic granofels, and biotite schist. Exposed in Weathershield on Pikes Peak . (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Rusty weathering, medium- to coarse-grained chlorite-biotite-muscovite-quartz schist typically containing staurolite and garnet porphyroblasts. Contacts with Scq are not exposed. Unit mapped as discontinuous horizons along the ridge of Green Mountain. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Scms - Clough Quartzite, muscovite schist member (Silurian)

Silver to light-gray, medium-grained, garnet-muscovite-quartz schist with ubiquitous pink garnets. 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. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Scq - Clough Quartzite, conglomerate member (Lower Silurian)

Scq - Clough Quartzite, conglomerate and quartzite member (Lower Silurian)
Undifferentiated massive, poorly bedded, weakly foliated, light gray, orange weathering quartzite with minor muscovite, well-bedded gray to orange, micaceous quartzite with beds from 1-cm- to 1-m-thick, and white to gray, muscovite-bearing quartz pebble to cobble metaconglomerate. Extremely rare, faintly visible cross-beds are locally preserved. Clasts are typically elongated with aspect ratios commonly exceeding 10:1, and consist dominantly of vein quartz and gray to white quartzite. Rare amphibolite found at one place on the northwest side of Green Mountain is mapped as "Scd". Contacts are typically sharp. May contain magnetite and, at higher metamorphic grades, chloritoid and garnet. Locally mylonitic along the Northey Hill fault zone. Fossils described by Boucot and others (1958) and Boucot and Thompson (1963) include tetracorals, brachiopods, pelycypods, and a possible trilobite and support a Llhandovery (Early Silurian) age. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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 Ledge's where the Clough Quartzite is bounded on both sides by the mélange unit DSm. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

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

Quartz diorite of the Lebanon dome – 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 1 of Walsh and others, 2012), the intruded Partridge Formation consists of rusty sulfidic, psammitic quartz-muscovite schist which was not mapped separately in this map area. The schist in the North Hartland quadrangle is generally more pelitic than the rock at Stop 1 of Walsh and others (2012). (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Op - Partidge Formation, sulfidic schist member (Ordovician)

Op - Partidge 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 and schist. Locally contains light- to dark-gray micaceous quartzite in thinly laminated layers or boudins and dark gray quartzite beds mapped separately as 'Opq'. Contains rare 1- to 3-m-thick, dark-green, epidote-chlorite-hornblende-plagioclase amphibolite dikes or metavolcanic layers mapped as 'Opa'. Quartzite (Opq) and amphibolite (Opa) units are exaggerated in size on the map to show their locations. 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 fault zone. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Op - Partidge Formation, sulfidic schist member (Ordovician)
Dark-gray to grayish-black, rusty-weathering, sulfidic, graphite±garnet-plagioclase-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. Contains lesser silvery gray garnet-muscovite-epidote-plagioclase-chlorite-biotite-quartz near the contact with the Ammonoosuc Volcanics. 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 with a few meters. Contacts with the Clough Quartzite are very sharp. 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Opa - Partidge Formation, sulfidic schist member: amphibolite dikes (Ordovician)

Opa - Partidge Formation, sulfidic schist member: amphibolite dikes (Ordovician)
Same lithological description as unit Op. Contains rare 1- to 3-m-thick, dark-green, epidote-chlorite-hornblende-plagioclase amphibolite dikes or metavolcanic layers mapped as 'Opa'. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Opa - Partidge Formation, sulfidic schist member: amphibolite dikes (Ordovician)
Same lithological description as unit Op. 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Opq - Partidge Formation, sulfidic schist member: quartzite (Ordovician)

Same lithological description as unit Op. Locally contains light- to dark-gray micaceous quartzite in thinly laminated layers or boudins and dark gray quartzite beds mapped separately as 'Opq'. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Opp - Partidge 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. Interpreted as a metasomatized version of the Partidge Formation sulfidic schist member. Rock occurs discontinuously along 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Oa - Ammonoosuc Volcanics, undifferentiated volcanic member (Ordovician)

Oa - Ammonoosuc Volcanics, undifferentiated volcanic member (Ordovician)
Heterogeneous assemblage of rock types consisting of dark greenish-gray fine to medium-grained, plagioclase-biotite-chlorite-quartz schist to phyllite, layered to massive greenstone and amphibolite (locally with garbenschiefer texture), felsic quartz-plagioclase granofels (metafelsite), limonite-muscovite quartzite, and sulfidic quartz-plagioclase schist. Locally contains minor carbonate, magnetite, and sulfides. At sub-garnet grade, the rocks are green, gray green, bluish green, silvery gray green, and green and white layered. In the garnet zone or higher, the rocks are darker green, gray green to black, and black and white layered. Locally contains pods and lenses of epidote, plagioclase and lesser quartz phenocrysts, deformed pillows, fiamme (eutaxitic texture), and volcanic breccia. Unit 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 either sharp or gradational by intercalation. Contacts with the Partridge Formation are generally sharp, but locally gradational. In tectonic contact with the rocks of the Connecticut Valley trough along the Monroe fault. Unit is generally well exposed in areas of abundant outcrop, especially on Wellmans Hill and Barber Mountain. (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

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. 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 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 contains pods and lenses of epidote, plagioclase and lesser quartz phenocrysts, deformed pillows, fiamme (eutaxitic texture), and volcanic breccia. (*GRI Source Map ID 76011*) (Hartland and N. Hartland Quads).

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 and schist. Resembles the Partridge Formation sulfidic schist member (Op) and may be correlative with it. Occurs on Dingleton Hill within the Cornish City belt of the Monroe thrust sheet. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Oaf - Ammonoosuc Volcanics, metafelsite member (Ordovician)

Oaf - Ammonoosuc Volcanics, metafelsite member (Ordovician)
Tan to light-gray weathering, ±muscovite-K-feldspar-chlorite-plagioclase-quartz schist, felsic granofels, felsic intrusive and minor quartz phenocryst-bearing rocks. Unit is interlayered with other members of the Ammonoosuc Volcanics. Interpreted as mostly metavolcanic, but some layers may represent intrusive sills. Well exposed on an unnamed hill 2 km north of Cornish City, on Ironwood Hill. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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, locally contains epidote and amphibole. Contains mm-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'; it contains metafelsite beds 5 - 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. Unit interpreted as felsic volcanic and volcaniclastic rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Oafa - Ammonoosuc Volcanics, bimodal metavolcanic member (Ordovician)

Oafa - Ammonoosuc Volcanics, bimodal metavolcanic member (Ordovician)
Interlayered greenstone and metamorphosed felsic volcanic and intrusive rocks. Typically green and white to dark green to black and white distinctly banded rocks. Contacts gradational with Oa and distinguished from Oa by the distinct alternating layering of felsic and mafic rocks; the latter of which resemble Oaa and Oaf where mapped separately. Unit hosts an abandoned zinc-sulfur-pyrite mine on Hanover Street in Claremont. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Oafa - Ammonoosuc Volcanics, bimodal metavolcanic member (Ordovician)
Same lithological description as unit Oaf. A belt of green and white banded rock on the west side of Fifield Hill is mapped separately as 'Oafa'; it contains metafelsite beds 5 - 30 cm thick interlayered with undifferentiated volcanic rocks. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Oar - 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. Interlayered with the undifferentiated Oa unit on the east side of Fifield Hill in Plainfield. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Oal - 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. Matrix is aphanitic with mm-size quartz and feldspar phenocrysts. 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. Unit interpreted as a pyroclastic volcanic rock. (*GRI Source Map ID 76011*) (Hartland and N. Hartland Quads).

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 mm- to cm-scale phenocrysts of quartz and feldspar and small cm-scale epidote pods. Contains accessory epidote and blue-green amphibole, and trace opaques. Unit exposed in Plainfield on the west side of Ladieu Hill; typical exposures occur along Ladieu Road west of Colby Hill. Unit is interlayered with the Oa unit. Unit interpreted as felsic volcanic and volcaniclastic rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Oaa - Ammonoosuc Volcanics, amphibolite member (Ordovician)

Oaa - Ammonoosuc Volcanics, greenstone and amphibolite member (Ordovician)
Dark green to black, massive to thickly layered actinolite-epidote-plagioclase-chlorite ± carbonate ± magnetite greenstone, schistose greenstone, or amphibolite. Locally rusty weathering. Epidote nodules and layers are common. Rarely contains deformed pillows. Deformed pillows were observed along the power line northwest of Cornish City. Overall, 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 garbenschiefer texture. Amphibolite is common south of Green Mountain. Well exposed west of Cornish City and on Wellmans Hill. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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. Unit exposed from Pinnacle Hill to ridge east of Mud Pond, west of Porter Road. Unit interpreted as mafic volcanic and

volcaniclastic rock. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Ochg - Cram Hill Formation, greenstone member (Ordovician)

Medium-green to gray-green, highly foliated, hornblende-plagioclase greenstone, marked by distinctive irregular, clots, or indistinct patches of more plagioclase-rich inclusions as much as 3 cm in length set in a more uniform amphibolite matrix. Unit interpreted as basaltic to andesitic tuff breccia and volcaniclastic rock. Mapped at one location in Weathersfield, north of Route 131, where it occurs below the unconformity at the base of the Connecticut Valley trough. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

A heterogeneous unit consisting of well layered, light-gray-weathering, felsic biotite-hornblende-quartz plagioclase gneiss intimately interlayered with darker 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. The rusty-weathering biotite-muscovite-quartz schist, feldspathic granofels and layers of coticule present throughout indicate a collection of volcaniclastic rocks and interbedded metasedimentary rocks, for this reason the unit is interpreted as a member of the Cram Hill Formation. Contact relations with underlying units uncertain, may disconformably overlie both the Moretown and metatrondhjemite (Ontd) of the North River Igneous Suite. Occurs below the unconformity at the base of the Connecticut Valley trough. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ochq - Cram Hill Formation, quartzite member (Ordovician)

Steel-gray- to yellow-tan-weathering quartzite and quartz-pebble conglomerate as much as 2-m-thick. Occurs along the contact with Omb and Ochv at one location in Weathersfield, north of Route 131. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ontd - Trondhjemite gneiss (Ordovician)

Principally, light-gray- to chalky-white-weathering, massive, medium-grained, biotite±garnet-quartz-plagioclase gneiss; lacks mafic layers present in the Ochv unit of the Cram Hill Formation and is interpreted as intrusive into the Omhfs unit of the Moretown Formation along the contact with Ochv. Alternatively it could be a metadacite. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ogd - Oliverian Plutonic Suite, granodiorite, trondhjemite and tonalite of the Sugar River pluton (Early 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 enriched in magnetite near the contact with the Ammonoosuc Volcanics suggesting

contact metasomatism. Enclaves and xenoliths of amphibolite are present locally and indicate that the rocks intruded the Ammonoosuc Volcanics. Mapped as the Sugar River pluton south of Green Mountain. A sample from the Sugar River pluton yields a U-Pb SHRIMP zircon age of 460±3 Ma (Valley and others, 2015). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Otp - Oliverian Plutonic Suite, 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. (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Ot - Oliverian Plutonic Suite, unnamed tonalite (Early Ordovician)

Light gray to gray, very light gray to orange weathering, medium-grained, ±garnet±hornblende±biotite-chlorite-plagioclase-quartz trondhjemite and tonalite. Locally contains characteristic small augen of quartz and lesser feldspar, up to 0.5 cm across. Occurs as abundant foliation-parallel lit-par-lit dikes or sills in the Ammonoosuc Volcanics in the central part of the map; unit mapped in the Cornish City belt and not in the Claremont belt. Unit is similar to and probably correlative with the Plainfield tonalite in the adjacent North Hartland quadrangle (Walsh, in press); there the tonalite yielded a U-Pb SHRIMP zircon age of 475 ± 5 Ma (Valley and Walsh, 2013; Valley and others, 2015). Well exposed on Wellmans Hill and southwest of Cornish City. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Omhfs - Moretown Formation, hornblende fasicle schist member (Cambrian to Ordovician)

Light-gray to gray-green, chlorite-muscovite-biotite plagioclase-quartz schist and granofels marked by conspicuous sprays of hornblende and distinctive, large 5-mm- to 1-cm-diameter porphyroblasts of cross-foliation biotite, and abundant irregular layers of coticule 1 to 2 cm thick, and abundant layers of pinstriped light-gray biotite-quartz granofels similar to Oml of Ratcliffe and others (2011). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Dark-gray to silvery-gray, garnet-biotite-muscovite carbonaceous schist, and associated rusty weathering muscovite-biotite-quartz schist. Unit contains layers rich in small garnet 1-2 mm in diameter, which resemble phyllites of the Whetstone Hill Member of the Moretown Formation (Ratcliffe and others, 2011). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Omrq - Moretown Formation, quartzite (Cambrian to Ordovician)

Light-tan-weathering, thinly layered muscovite-biotite-plagioclase quartzite; occurs in contact with Omgt and as layers within Omb. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Omgt - 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 prophyroblasts; occurs in depositional contact with Omb about 1 km west of Brownsville in the northwest part of the map. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

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

Green schist and granofels member – Principally 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 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 Oml unit of Ratcliffe and others (2011); beds of coticule 1- to 2-cm-thick "c", or layers of dark-green wellfoliated amphibolite may be abundant. Distinctive porphyroblasts of cross-foliation biotite occur throughout; 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 regionally (Ratcliffe and others, 2011) with which these rocks have been correlated by Thompson and others (1993). Unit is in fault contact with Middle Proterozoic rocks at its base and is bedded with and gradational upwards into Omb. Unit well-exposed both northeast and southeast of Ascutney Notch and the Cretaceous gabbro and diorite of the Little Ascutney stock. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Omfsc - Moretown Formation, coticule (Cambrian to Ordovician)

Same lithological description as unit Omfs (above). Beds of coticule 1- to 2-cm-thick "c". (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Oma - Moretown Formation, amphibolite (Cambrian to Ordovician)

Dark-green, highly foliated epidote-biotite-hornblende and hornblende-plagioclase amphibolite, varies from highly foliated and epidote-podded to a more granular rock consisting of approximately 70 percent hornblende and 30 percent plagioclase. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

OZu - Moretown Formation, talc-carbonate schist (Ordovician and Neoproterozoic?)

Cream-colored to light-bluish-gray, brown-weathering, talc-carbonate schist and dark-green serpentinite. Exposed in one place in the Omb black schist member of Moretown Formation south of Cady Hill Road in Weathersfield. Contacts are not exposed. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Y1bm - Baileys Mills tonalitic gneiss of the Mount Holly Complex (Middle Proterozoic)

Coarse-biotite-flecked, light-gray to whitish-gray weathering, medium-grained, biotite-quartz-plagioclase gneiss, having a distinctive non-gneissic, igneous appearing texture, in less sheared rocks. Contains numerous inclusions of coarse biotite amphibolite mapped as Ya that may be, in part, comagmatic dikes of metagabbro. Passes into lighter gray, more leucocratic, biotite trondhjemite gneiss. Yielded a U-Pb zircon SHRIMP age of 1,383±13 Ma (Ratcliffe and others, 1991; Aleinikoff and others, 2011). Well-exposed along the power line southwest of Nelsons Corner. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Y1bmp - Mount Holly Complex, tonalite gneiss (Middle Proterozoic)

Very-well foliated, mylonitic, biotite gneiss containing porphyroclastic eyes of plagioclase as much as 5 mm long set in a mylonitic matrix rich in biotite; 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). Well-exposed along the power line southeast of Nelsons Corner. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ycfs - Cavendish Formation, Feldspathic schist or granofel (Middle Proterozoic)

Either a rusty-weathering, light- to medium-dark gray, white-plagioclase-spotted, biotite-quartz granofels or a biotite-rich porphyroclastic schist having isolated augen of plagioclase, as much as 1 cm in diameter set in a phyllonitic matrix of biotite, muscovite, epidote, and quartz. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ycm - Cavendish Formation, marble (Middle Proterozoic)

Consists of a variety marbles intimately associated with calc-silicate gneiss and or beds of actinolitic quartzite, including, whitish-gray weathering, medium- to coarse-grained, phlogopite-calcite-dolomite and quartz-knotted marble; greenish actinolite-rich dolomitic marble; fine-grained yellow-gray weathering, highly foliated phlogopite-talc(?)-tremolite-dolomite marble. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ybg - Mount Holly Complex, biotite-quartz-plagioclase gneiss (Middle Proterozoic)

A heterogeneous assemblage of dark- to medium-gray, non-rusty-weathering, quartz-rich biotitic gneisses, all characterized by having abundant plagioclase and epidote and little or no microcline. Distinctive other rock types include: light-gray-weathering, magnetite-muscovite-biotite plagioclase-quartz gneiss containing thin layers of hornblende-spotted gneiss; a very dark-gray, biotite-rich plagioclase-quartz gneiss commonly associated with epidotic quartzite, and medium- to dark-gray, white-albite-spotted-biotite-quartz gneiss. Muscovite is a common accessory in most rocks and small garnet may be present as well. The biotite-quartz- plagioclase gneiss unit contains numerous layers of other distinctive rocks interlayered throughout; where thick enough to map, these units, listed below, are mapped separately. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Ya - Mount Holly Complex, amphibolite (Middle Proterozoic)

Dark-green- to dull-gray-weathering, fine- to coarse-grained, biotite hornblende and hornblende-garnet-plagioclase amphibolite, commonly associated with Y2rs or Ybg. (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Y2rs - Mount Holly Complex, rusty muscovite-biotite-plagioclase-quartz gneiss (Middle Proterozoic)

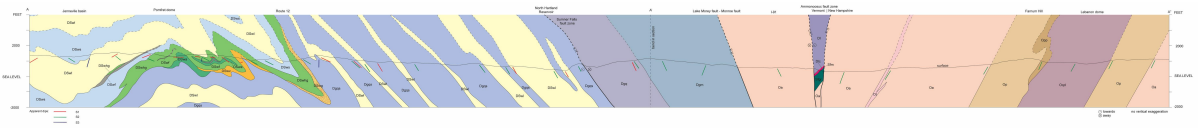
Dark-brown to gray, rusty weathering, gneiss and schist containing abundant layers of schistose quartzite, biotite-garnet quartzite, and rusty sulfidic amphibolite. Locally passes into more muscovitic, lustrous, chlorite-garnet-schist mapped in the adjacent Chester and Cavendish quadrangles as unit Yrs, but here not distinguished separately (Ratcliffe, 1995a; 1995b; 2000a; 2000b). (*GRI Source Map ID 76010)* (Mt. Ascutney 7.5 x 15 Minute Quad).

Geologic Cross Sections

The geologic cross sections present in the GRI digital geologic-GIS data produced for Saint-Gaudens National Historic Site, New Hampshire and Vermont (SAGA) are presented below. Note that cross section abbreviations on the Mt. Ascutney map have been changed from their source map abbreviation so that each cross section abbreviation is unique in the GRI digital data (e.g., A-A' on the Mt. Ascutney map has been changed to D-D' in the GRI digital data). 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).

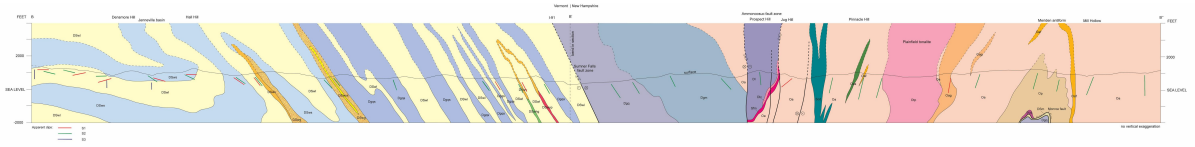
Hartland Cross Sections

Cross Section A-A''



Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Cross Section B-B''



Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Cross Section C-C'''

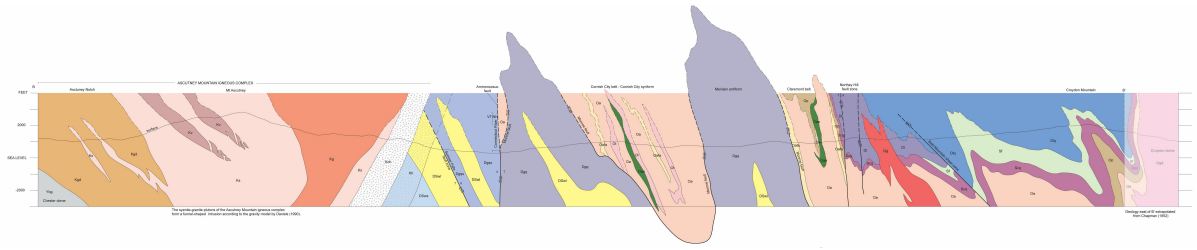
Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Mt. Ascutney Cross Sections

Cross Section D-D''

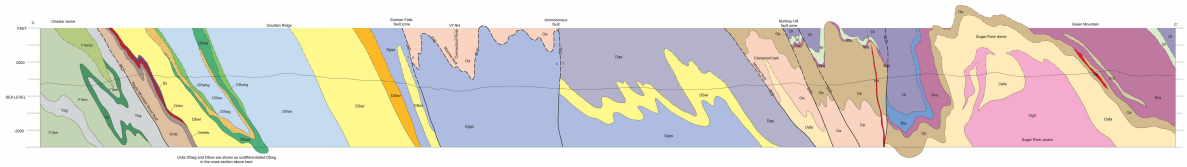
Cross section is A-A" on source map. Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Cross Section E-E'



Cross section is B-B' on source map. Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Cross Section F-F'



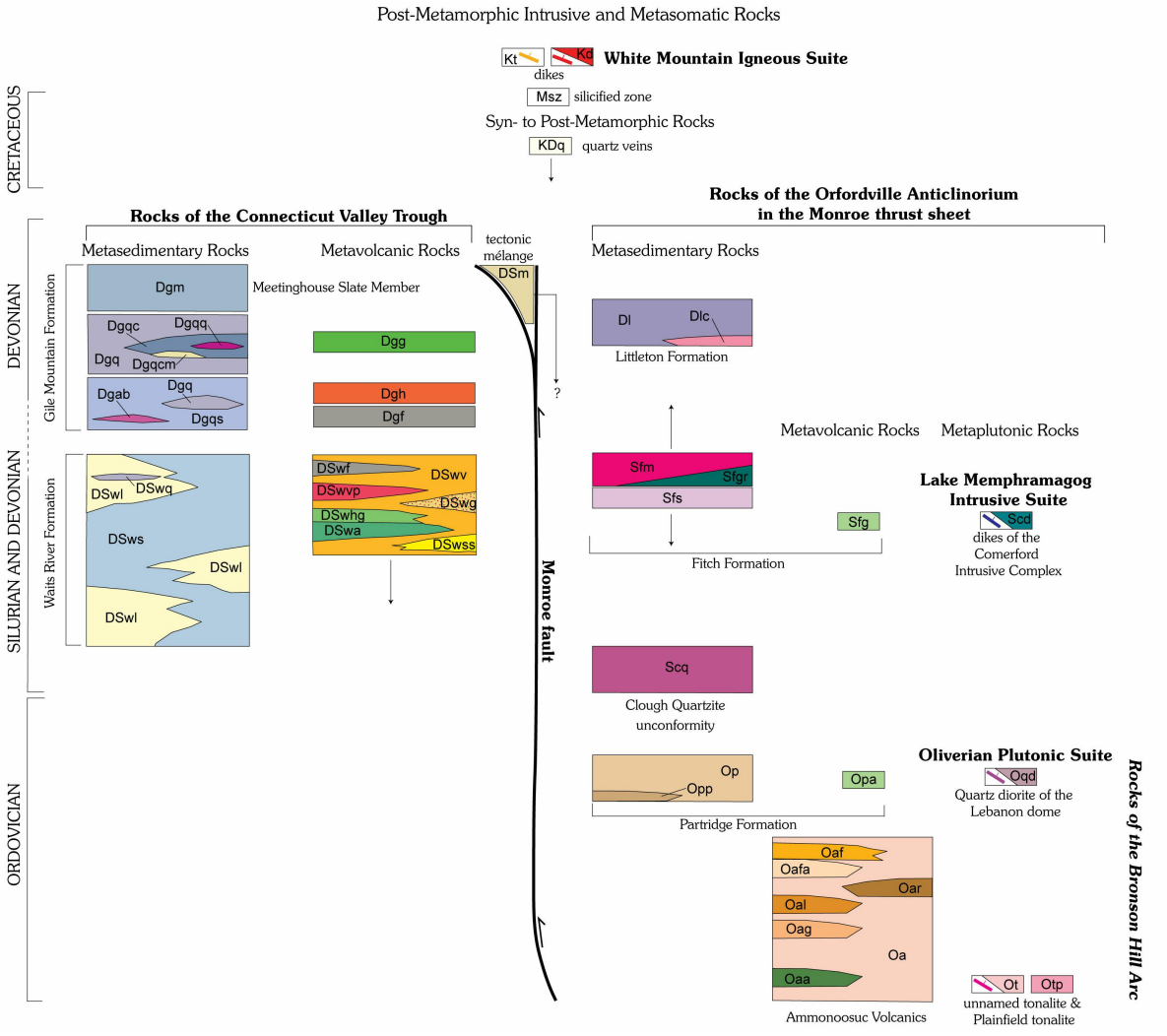
Cross section is C-C' on source map. Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

GRI Source Map Information

Hartland Scientific Investigation Map SIM-xxxx

Walsh, Gregory J., 2015, 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 Investigation Map SIM-xxxx, scale 1:24000. (Hartland and N. Hartland Quads) (*GRI Source Map ID 76011).*

Correlation of Map Units

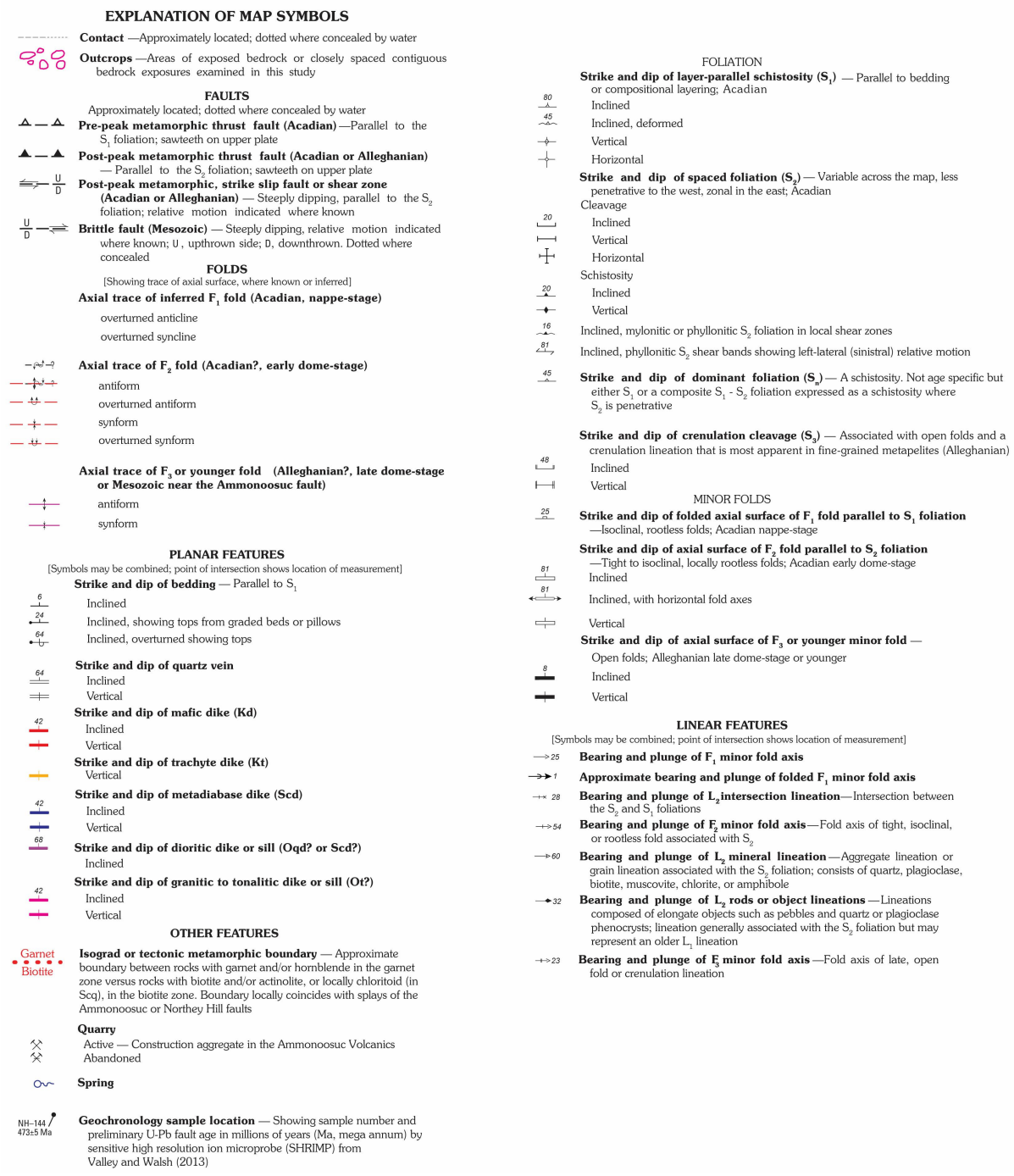


Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Quadrangle Location

Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Map Legend



EXPLANATION OF MAP SYMBOLS

Contact —Approximately located; dotted where concealed by water

Outcrops —Areas of exposed bedrock or closely spaced contiguous bedrock exposures examined in this study

FAULTS

Approximately located; dotted where concealed by water

Pre-peak metamorphic thrust fault (Acadian) —Parallel to the S_1 foliation; sawteeth on upper plate

Post-peak metamorphic thrust fault (Acadian or Alleghanian) — Parallel to the S_2 foliation; sawteeth on upper plate

Post-peak metamorphic, strike slip fault or shear zone (Acadian or Alleghanian) — Steeply dipping, parallel to the S_2 foliation; relative motion indicated where known

Brittle fault (Mesozoic) — Steeply dipping, relative motion indicated where known; U, upthrown side; D, downthrown. Dotted where concealed

FOLDS

[Showing trace of axial surface, where known or inferred]

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

overturned anticline

overturned syncline

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

antiform

overturned antiform

synform

overturned synform

Axial trace of F_3 or younger fold (Alleghanian?, late dome-stage or Mesozoic near the Ammonoosuc fault)

antiform

synform

PLANAR FEATURES

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

Strike and dip of bedding — Parallel to S_1

Inclined

Inclined, showing tops from graded beds or pillows

Inclined, overturned showing tops

Strike and dip of quartz vein

Inclined

Vertical

Strike and dip of mafic dike (Kd)

Inclined

Vertical

Strike and dip of trachyte dike (Kt)

Vertical

Strike and dip of metadiabase dike (Scd)

Inclined

Vertical

Strike and dip of dioritic dike or sill (Oqd? or Scd?)

Inclined

Strike and dip of granitic to tonalitic dike or sill (Ot?)

Inclined

Vertical

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. Boundary locally coincides with splays of the Ammonoosuc or Northey Hill faults

Quarry

Active — Construction aggregate in the Ammonoosuc Volcanics

Abandoned

Spring

NH–144 / 473±5 Ma — **Geochronology sample location** — Showing sample number and preliminary U-Pb fault age in millions of years (Ma, mega annum) by sensitive high resolution ion microprobe (SHRIMP) from Valley and Walsh (2013)

FOLIATION

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

Inclined

Inclined, deformed

Vertical

Horizontal

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

Cleavage

Inclined

Vertical

Horizontal

Schistosity

Inclined

Vertical

Inclined, mylonitic or phyllonitic S_2 foliation in local shear zones

Inclined, phyllonitic S_2 shear bands showing left-lateral (sinistral) relative motion

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

Strike and dip of crenulation cleavage (S_3) — Associated with open folds and a crenulation lineation that is most apparent in fine-grained metapelites (Alleghanian)

Inclined

Vertical

MINOR FOLDS

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

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

Inclined

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 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_2 and S_1 foliations

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

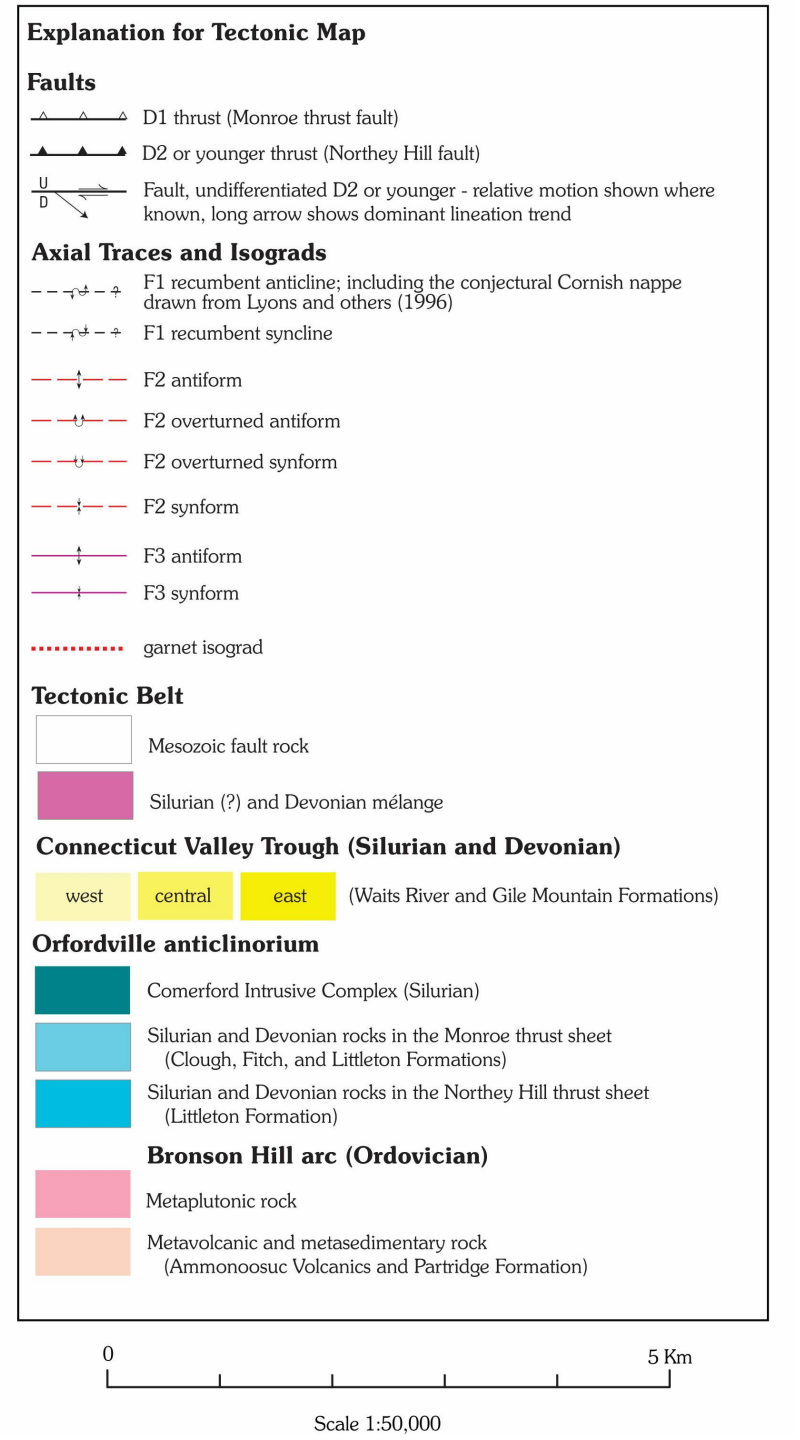
Bearing and plunge of L_2 mineral lineation—Aggregate lineation or grain lineation associated with the S_2 foliation; consists of quartz, plagioclase, biotite, muscovite, chlorite, or amphibole

Bearing and plunge of L_2 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

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

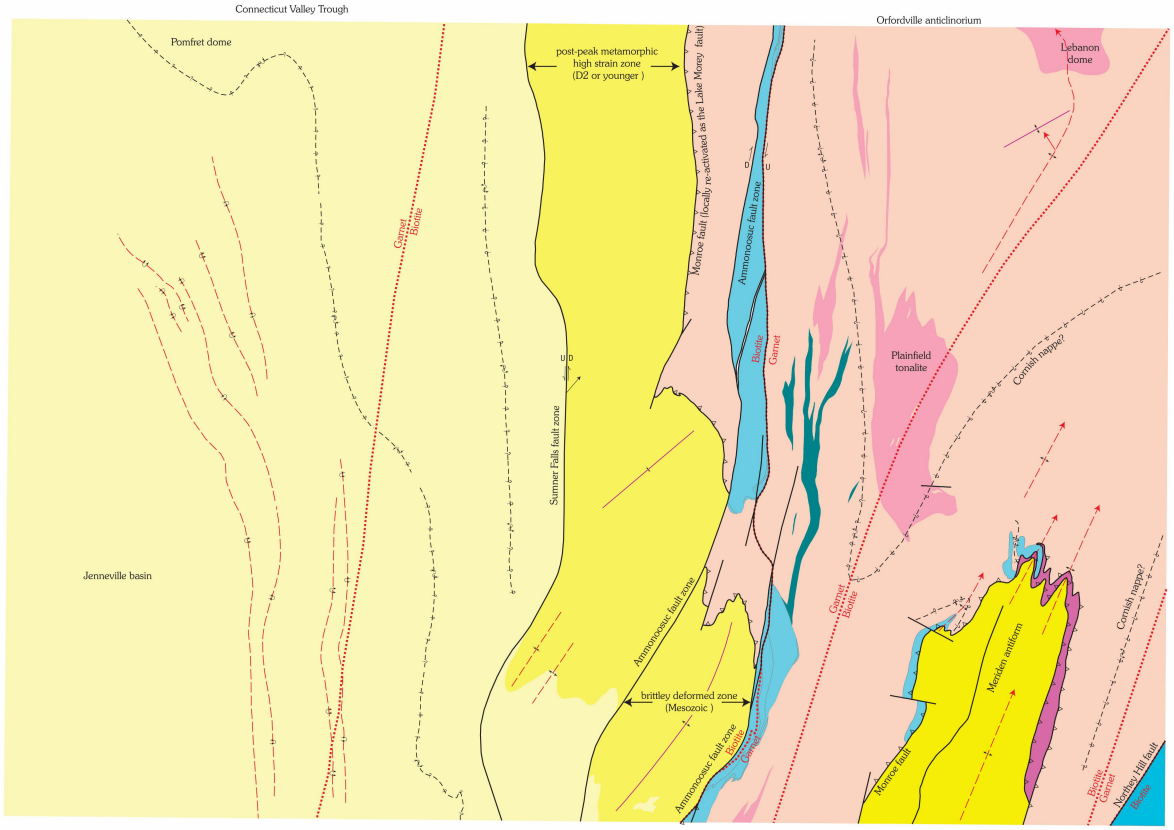
Extracted from: (*GRI Source Map ID 76011*) (Hartland and N. Hartland Quads).

Tectonic Map Legend



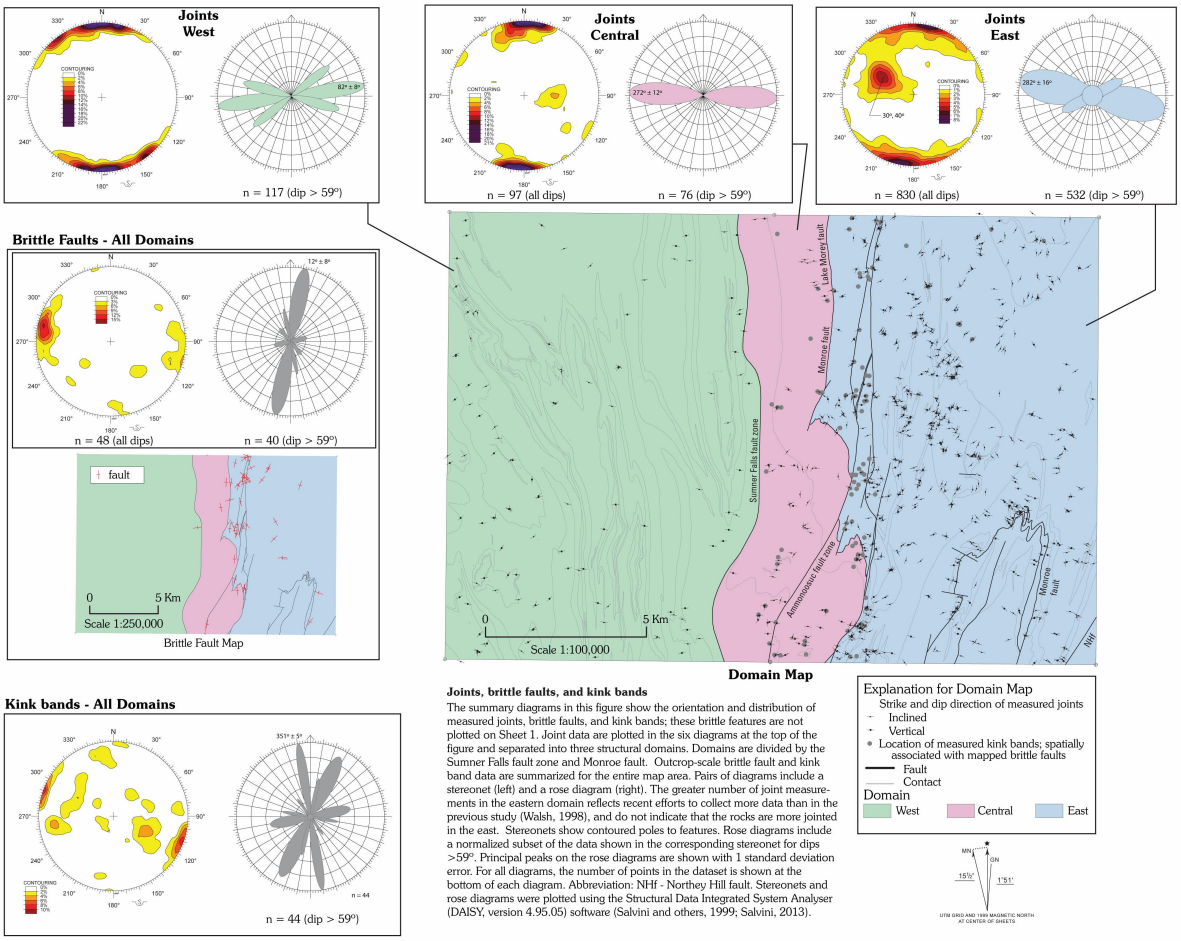
Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Tectonic Map



Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Brittle Features



Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Abstract

The bedrock geology of the 7.5- by 15-minute Hartland and North Hartland, VT-NH quadrangles 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 Bronson Hill anticlinorium. 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 overlain by Silurian to Devonian Clough, Fitch, and Littleton Formations (Lyons and others, 1997). Rocks of the Connecticut Valley trough in this map 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). In this map, however, only the Waits River and Gile Mountain Formations are exposed.

Syn to post-metamorphic 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 Fitch and Littleton formations. The Monroe thrust sheet placed the BHA rocks over the Connecticut Valley trough 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 mélange 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 fault zone truncated peak-metamorphic assemblages, isograds, and older F1 folds and faults. Late-stage F3 folds show preferred left-lateral rotation sense (see 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 (see sheet 2).

Currently the 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, NH.

This report includes two color maps (sheets 1 and 2) and a database including contacts of bedrock geologic units, faults, outcrops, structural geologic information, and photographs. The complete report is available online at: http://pubs.usgs.gov/SIM/xx/

Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Plate 1 References

Armstrong, T. R., Walsh, G. J., and Spear, F. S., 1997, A transect across the Connecticut Valley sequence in east-central Vermont. Trip A6, in Grover, T. W., Mango, H. N., and Hasenohr, E. J., editors, Guidebook to field trips in Vermont and adjacent New Hampshire and New York: Castleton, Vermont, New England Intercollegiate Geological Conference, 89th Annual meeting, Castleton State College, p. A6-1–A6-56.

Foland, K.A., Henderson, C.M.B., and Gleason, Jim, 1985, Petrogenesis of the magmatic complex at Mount Ascutney, Vermont, USA, I. Assimilation of crust by mafic magmas based on Sr and O isotopic and major element relationships: Contributions to Mineralogy and Petrology, v. 90, p. 331-345.

Kaiser, E.P., 1938, Geology of the Lebanon granite: American Journal of Science, v. 37, p. 107-136.
Lyons, J.B., 1955, Geology of the Hanover quadrangle, New Hampshire - Vermont: Geological Society of America Bulletin, v.66, scale 1:62,500.

Lyons, J. B., Bothner, W. A., Moench, R. H., and Thompson, J. B., 1997, Bedrock geologic map of New Hampshire: U.S. Geological Survey, scale 1:250,000.

McHone, J.G., 1984, Mesozoic igneous rocks of northern New England and adjacent Québec: Summary, description of map, and bibliography of data sources: Geological Society of America Map and Chart Series MC-49, scale 1:690,000.

McHone, J.G., and McHone, N.W., 2012, Mesozoic dikes and tectonic features in the central Connecticut River valley, Vermont and New Hampshire, *in* Thompson, P.J., and Thompson, T.B., editors, Guidebook to field trips in western New Hampshire and adjacent Vermont and Massachusetts, 104th

New England Intercollegiate Geological Conference, Mount Sunapee, New Hampshire, p. C2-1 – C2-18.

Rankin, D. W., Coish, R. A., Tucker, R. D., Peng, Z. X., Wilson, S. A., and Rouff, A. A., 2007, Silurian extension in the upper Connecticut Valley, United States and the origin of middle Paleozoic basins in the Québec embayment: American Journal of Science, v. 307, p. 216–264.

Ratcliffe, N.M., Stanley, R.S., Gale, M.H., Thompson, P.J., and Walsh, G.J., 2011, Bedrock geologic map of Vermont: U.S. Geological Survey Scientific Investigations Map 3184, 3 sheets, scale 1:100,000.

Raymond, L.A., 1984, Classification of mélanges, in Raymond, L.A., editor, Mélanges: Their Nature, Origin, and Significance: Geological Society of America Special Paper 184, Boulder, CO, p. 7-20.

Thompson, P.J., Robinson, Peter, and Wise, D.U., 2012, geology of Skitchewaug Mountain, Vermont and adjacent New Hampshire: A reprise of Jim Thomposn's 1954 NEIGC trip and consequences for regional geology, in Thompson, P.J., and Thompson, T.B., editors, Guidebook to field trips in western New Hampshire and adjacent Vermont and Massachusetts, 104th New England Intercollegiate Geological Conference, Mount Sunapee, New Hampshire, p. B4-1 - B4-11.

Valley, P.M., and Walsh, G.J., 2013, New U-Pb zircon ages from the Bronson Hill anticlinorium, west-central New Hampshire: Geological Society of America, Abstracts with Programs, v. 45, no. 1, p. 108.

Walsh, G.J., 1998, Digital bedrock geologic map of the Vermont part of the Hartland quadrangle, Windsor County, Vermont: U.S. Geological Survey Open File Report 98-123, 17 p., scale 1:24,000.

Walsh, G.J., Armstrong, T.R., and Ratcliffe, N.M., 1996a, Preliminary bedrock geologic map of the Vermont part of the 7.5 x 15 minute Mount Ascutney and Springfield quadrangles, Windsor County, Vermont: U.S. Geological Survey Open File Report 96-719, 38 p., scale 1:24,000.

Walsh, G.J., Armstrong, T.R., and Ratcliffe, N.M., 1996b, Digital bedrock geologic map of the Vermont part of the 7.5 x 15 minute Mount Ascutney and Springfield quadrangles, Vermont: U.S. Geological Survey Open File Report 96-733, scale 1:24,000.

Walsh, G.J., Merschat, Arthur, McAleer, R.J., Valley, P.M., Armstrong, T.R., Thompson, P.J., Roden-Tice, M.K., Iriondo, Alexander, and Kunk, M.J., 2014, Tectonic evolution and exhumation of the lower structural levels of the Bronson Hill anticlinorium in southwestern New Hampshire and adjacent Vermont: Geological Society Of America, Abstracts With Programs, v. 46, no. 2, p. 96.

Walsh, G.J., Valley, P.M., and Sicard, K.R., 2012, A transect through the base of the Bronson Hill anticlinorium in western New Hampshire, in Thompson, P.J., and Thompson, T.B., editors, Guidebook to field trips in western New Hampshire and adjacent Vermont and Massachusetts, 104th New England Intercollegiate Geological Conference, Mount Sunapee, New Hampshire, p. A4-1 - A4-21.

Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Plate 2 References

Lyons, J.B., Campbell, J.G., and Erikson, J.P., 1996, Gravity signatures and geometric configurations of some Oliverian plutons: Their relation to Acadian structures: GSA Bulletin, v. 108, no. 7, p. 872–882.

Salvini, F., Billi, A., Wise, D.U., 1999, Strike-slip fault-propagation cleavage in carbonate rocks: the Mattinata fault zone, Southern Apennines, Italy: Journal of Structural Geology, v. 21, p. 1731-1749.

Salvini, F., 2013, DAISY 3; The Structural Data Integrated System Analyser (version 4.95.05): Rome, Italy, Università Degli Studi Roma Tre, Dipartimento di Scienze Geologiche, software available at http://host.uniroma3.it/progetti/fralab/Downloads/Programs/.

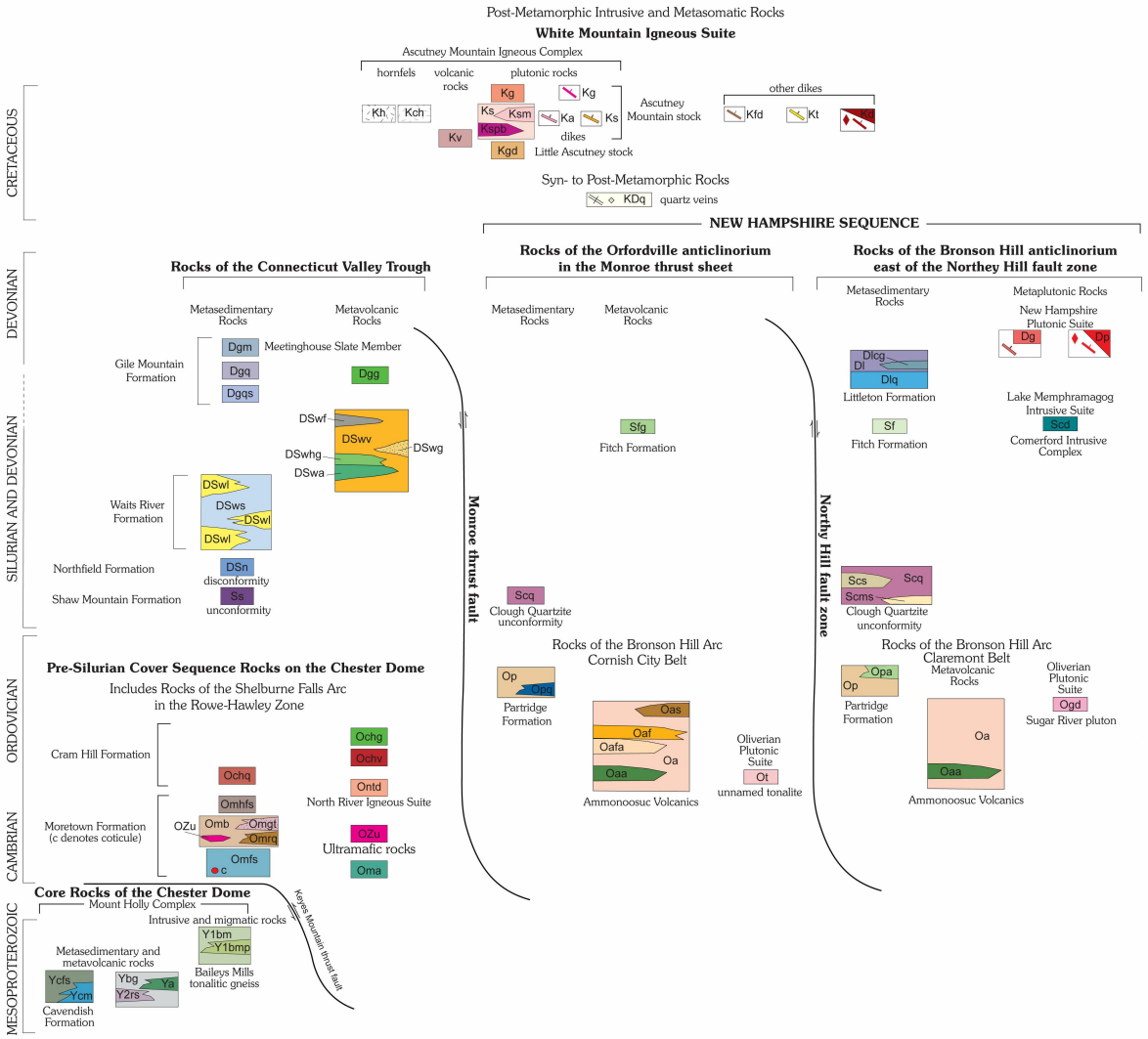
Walsh, G.J., 1998, Digital bedrock geologic map of the Vermont part of the Hartland quadrangle, Windsor County, Vermont: U.S. Geological Survey Open File Report 98 123, 17 p., scale 1:24,000.

Extracted from: (*GRI Source Map ID 76011)* (Hartland and N. Hartland Quads).

Mt. Ascutney Scientific Investigation Map SIM-xxxx

Walsh, Gregory J., Valley, Peter M., Thompson, Peter J., Ratcliffe, Nicholas M., Proctor, Brooks P., Sicard, Karri R. and Thompson, James B., 2015, Bedrock Geologic Map of the Mt. Ascutney 7.5 x 15 Minute Quadrangle, Windsor County, Vermont and Sullivan County, New Hampshire: U.S. Geological Survey, Scientific Investigation Map SIM-xxxx, scale 1:24000. (Mt. Ascutney 7.5 x 15 Minute Quad) (*GRI Source Map ID 76010).*

Correlation of Map Units

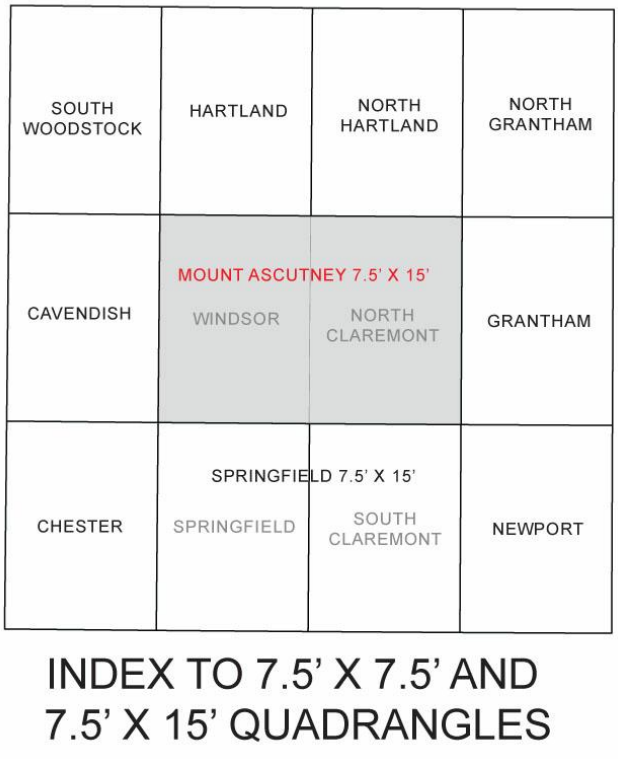


Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Quadrangle Location

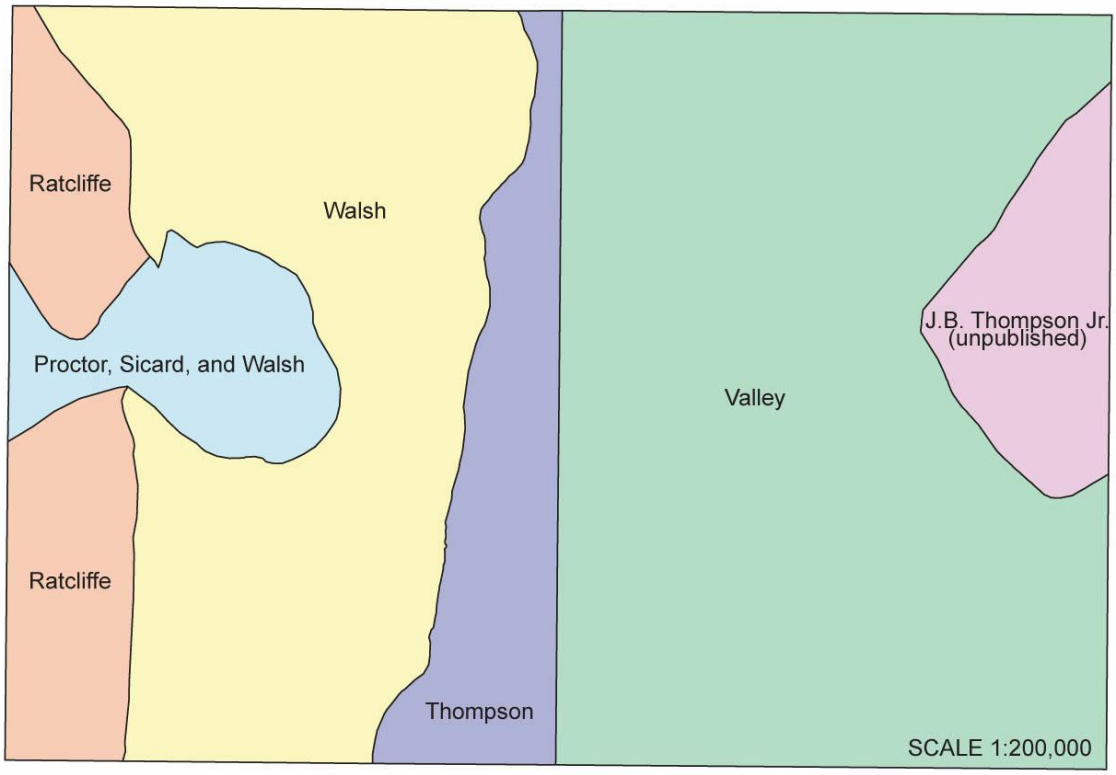
Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Index Map



Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Index to Geologic Mapping



Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Map Legend

EXPLANATION OF MAP SYMBOLS

Contact —Approximately located; dotted where concealed by water

Outcrops —Areas of exposed bedrock or closely spaced contiguous bedrock exposures examined in this study

FAULTS

Approximately located; dotted where concealed by water

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

Post-peak metamorphic, strike slip fault or shear zone (Alleghanian) — Steeply dipping, parallel to the S_2 or younger foliation; relative motion indicated where known. Includes the Sumner Falls, Northey Hill, and Bald Mountain fault zones

Unnamed brittle fault (Mesozoic) — Steeply dipping, relative motion indicated where known; U, upthrown side; D, downthrown. Dotted where concealed

FOLDS

[Showing trace of axial surface, where known or inferred]

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

recumbent anticline

recumbent 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

PLANAR FEATURES

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

Strike and dip of bedding — Parallel to S_1

Inclined

Inclined, showing tops from graded beds or pillows

Inclined, overturned showing tops

Strike and dip of quartz vein

Inclined

Vertical

Location only, no orientation measured

Strike and dip of mafic dike (Kd)

Inclined

Vertical

Location only, no orientation measured

Strike and dip of trachytic dike (Kt)

Vertical

Strike and dip of spherulitic felsic dike (Kfd)

Inclined

Strike and dip of granitic dike (Kg)

Inclined

Vertical

Strike and dip of aplite dike (Ka)

Inclined

Vertical

Strike and dip of syenitic dike (Ks)

Inclined

Vertical

Strike and dip of granitic dike (Dg)

Inclined

Strike and dip of pegmatite dike or sill (Dp)

Inclined

Location only, no orientation measured

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, and sillimanite-muscovite assemblages in the sillimanite zone. Boundary locally coincides with the Northey Hill fault zone or Bald Mountain shear zone

Quarry or Mine

Abandoned; showing names of 4 quarries in the Ascutney stock and one zinc (Zn) resource at the Claremont mine

Spring

NH–144 / 473±5 Ma — **Geochronology sample location** — Showing sample number and preliminary U-Pb fault age in millions of years (Ma, mega annum) by sensitive high resolution ion microprobe (SHRIMP) from Valley and Walsh (2013)

FOLIATION

Planar features in the pre-Silurian rocks of the Rowe-Hawley zone or Chester dome

Strike and dip of inclined gneissic layering of Proterozoic age; may be present small-scale xenoliths in the Little Ascutney stock

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

Strike and dip of inclined penetrative schistosity

Strike and dip of inclined schistosity of indeterminate age parallel to compositional layering

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

Planar features in the rocks 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

Horizontal

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

Horizontal

Schistosity

Inclined

Vertical

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

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

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

MINOR FOLDS

Folds in the pre-Silurian rocks of the Rowe-Hawley zone and Chester dome

Strike and dip of inclined axial surface of minor isoclinal fold of schistosity or gneissosity parallel to composite first and second generation schistosity; probably Taconian; arrow shows bearing and plunge of hinge line of fold; minor folds concentrated near and parallel to fault between the core gneisses and pre-Silurian cover rocks of the Chester dome

Strike and dip of axial surface of minor fold parallel to non-penetrative cleavage, arrow shows bearing and plunge of hinge line of fold; may correlate with F2 and F3 folds in the Silurian and Devonian rocks

Inclined

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

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

Inclined

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 F_4

Inclined

Vertical

Strike and dip of kink bands (S_4) — Mesozoic

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_2 and S_1 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

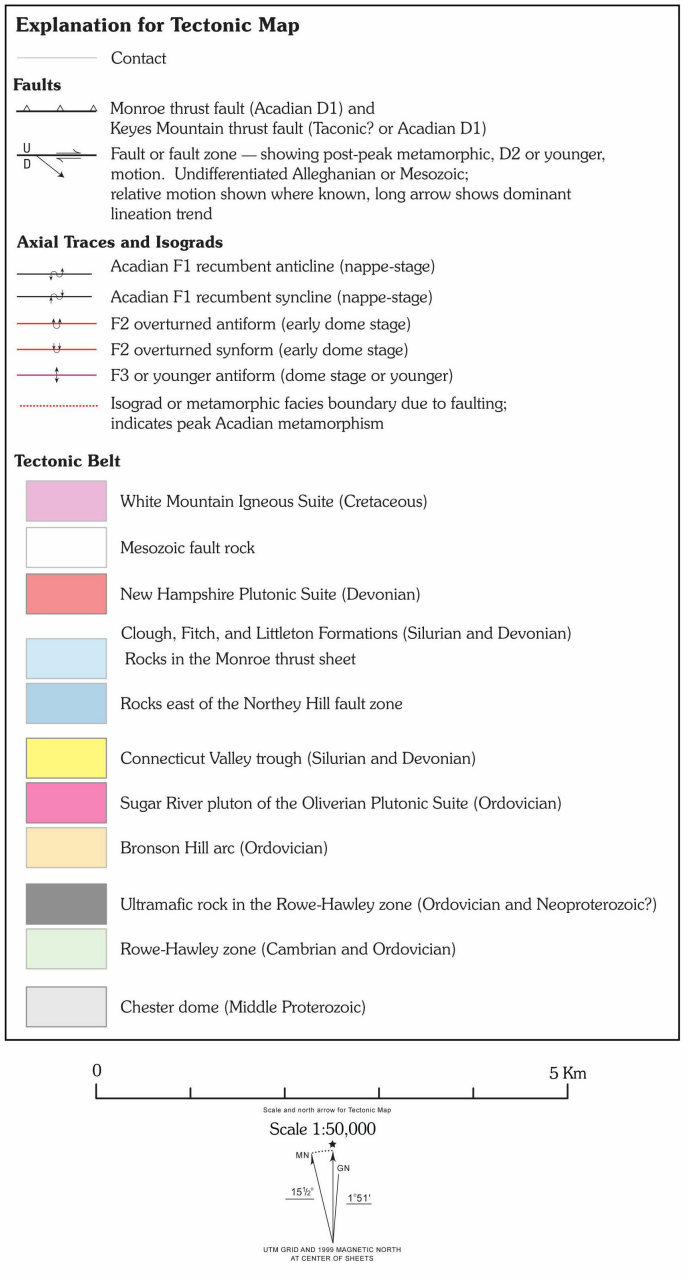
Bearing and plunge of L_2 rods or object lineations—Lineations composed of elongate objects such as pebbles and quartz or plagioclase phenocrysts; lineation generally associated with the S_2 foliation but may represent an older L_1 lineation. The same symbol is used for the pre-Silurian rocks west of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

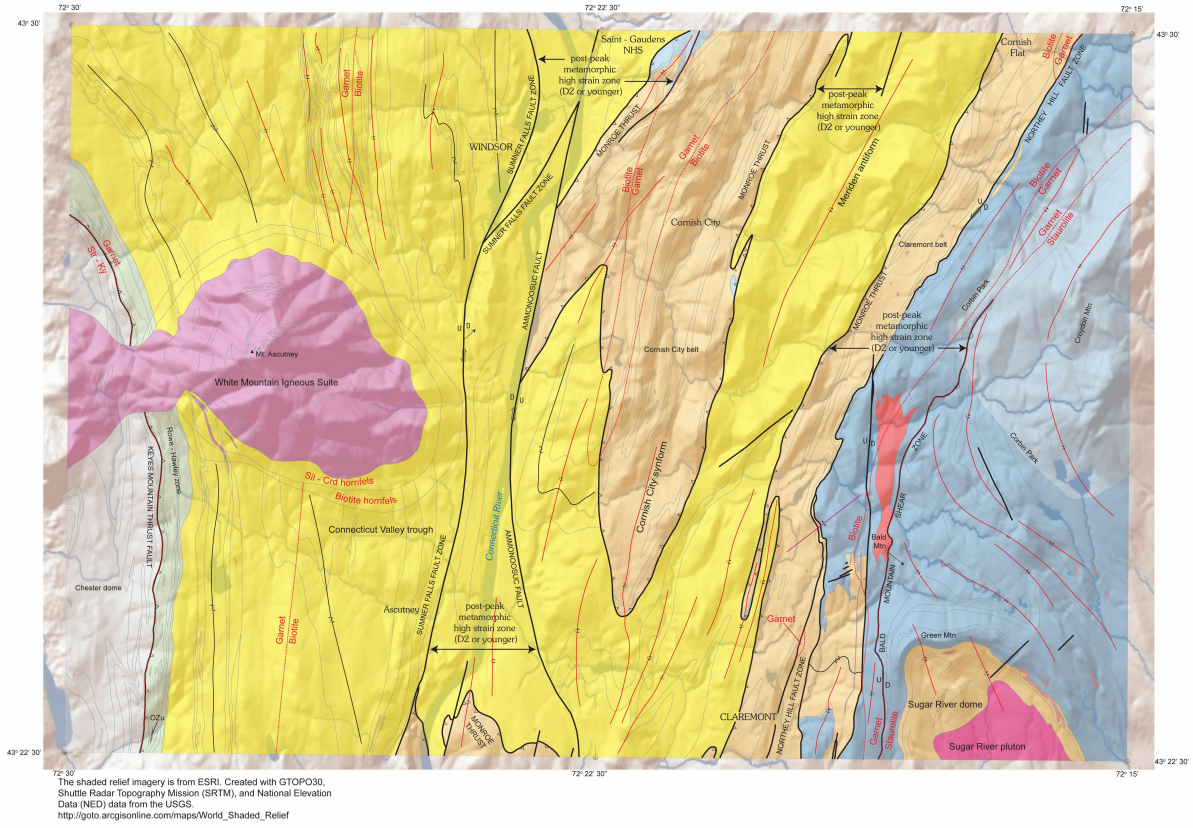
Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Tectonic Map Legend



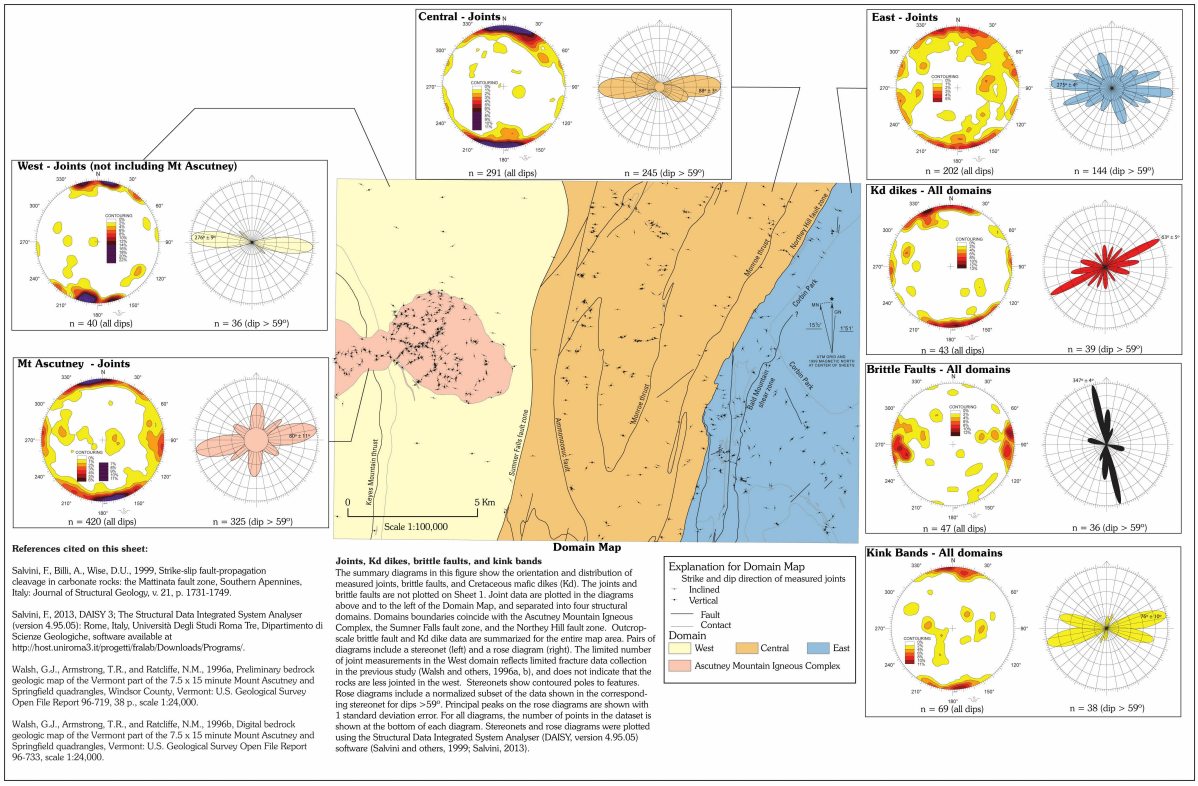
Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Tectonic Map



Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Brittle Features



Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Photo

Photograph of Mount Ascutney and the Cornish covered bridge from Cornish, NH looking southwest across the Connecticut River towards Vermont. Photograph by G. J. Walsh.

Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Abstract

The bedrock geology of the 7.5- by 15-minute Mount Ascutney 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 Rowe-Hawley zone includes the Moretown and Cram Hill formations and the North River Igneous Suite. The Rowe-Hawley zone structurally overlies the Chester dome along the Keyes Mountain thrust fault (Ratcliffe, 2000a, b; Ratcliffe and others, 2011), which represents the ancient Ordovician suture (Red Indian line) between crustal blocks with Laurentian versus Ganderian affinity (Macdonald and others, 2014; Valley and others, 2015). Silurian and Devonian metasedimentary and metavolcanic rocks of the Connecticut Valley trough (CVT) unconformably overlie the Rowe-Hawley zone. The easternmost extent of the CVT in New Hampshire is exposed in the Meriden antiform. Ordovician to Silurian and Devonian metasedimentary rocks of the New Hampshire sequence (Billings, 1937, 1956; White and Jahns, 1950; Ratcliffe and others, 2011; Rankin and others, 2013) structurally overlie the CVT along the Monroe thrust fault. The oldest part of the New Hampshire sequence (NHS) consists of Ordovician metamorphosed volcanic,

plutonic, and metasedimentary rocks of the Ammonoosuc Volcanics, the Partridge Formation, and the Oliverian Plutonic Suite. The Ammonoosuc Volcanics represent the base of the exposed section in the area. The Bronson Hill arc rocks may be partly correlative with rocks in the Rowe-Hawley zone (Valley and others, 2015). The Bronson Hill arc rocks are exposed in two fault-bounded structural belts – the Cornish City and Claremont belts, and in the Sugar River dome. Collectively, these belts form the regional Orfordville anticlinorium and the western part of the broader Bronson Hill anticlinorium in western New Hampshire. Silurian to Devonian metasedimentary rocks of the Clough Quartzite, and Fitch and Littleton Formations unconformably overlie the Bronson Hill arc rocks. Devonian granitic and pegmatitic dikes and sills of the New Hampshire Plutonic Suite intruded previously deformed rocks. Post-tectonic Cretaceous plutonic and volcanic rocks of the Ascutney Mountain Igneous Complex underlie Mount Ascutney and occur as mafic and felsic dikes throughout the map area. 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 Asutney Mountain stock is a funnel shaped composite pluton in agreement with geophysical data (Daniels, 1990).

The oldest structure is a relict gneissosity in the Mesoproterozoic Mount Holly Complex in the Chester dome. At or near the contact with the Rowe-Hawley zone 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, both of the gneissosity in the Mount Holly Complex and the schistosity in the overlying pre-Silurian rocks, and this fabric is interpreted as a relict Taconian foliation perhaps related to movement along the Keyes Mountain thrust fault. Almost certainly Acadian foliation is developed in the pre-Silurian Rowe-Hawley rocks, but we think that it is sub-parallel to the older Taconian schistosity. Conversely, 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, NH 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 F1) with generally north or south gently plunging fold hinges. These folds are the classic 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 CVT and NHS rocks possess this first generation (Acadian S1) schistosity, but they do not appear to have developed under the same metamorphic conditions. The S1 foliation in the NHS appears to have developed prior to or during peak metamorphism as high as staurolite grade (Walsh and others, 2012), but the S1 foliation in the western part of the Connecticut Valley trough developed prior to the peak of upper greenschist facies metamorphism which, based upon porphyroblast-fabric relative-age relationships, occurred syn- to post-Acadian S2 development. The second generation planar fabric in all of the Silurian and Devonian rocks (Acadian S2) varies from a non-penetrative cleavage to a penetrative schistosity. Folds associated with the second generation planar fabric (Acadian F2) 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 these 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 cross-cutting relative age relationships can be discerned, a dominant foliation symbol is used on the map (Sn). Acadian S1 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 mm to cm spaced cleavage (S3). These structures have many different orientations, although they most commonly strike northeast and 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 Acadian to neo-Acadian or Alleghanian, and the S3 fabric is probably Alleghanian. Late-stage F3 folds locally show preferred left-lateral rotation sense and are probably related to late dome-stage Alleghanian deformation or motion along lower greenschist facies faults such as the Sumner Falls and the Northey Hill fault zones. This activity may be related to ca. 300 Ma movement along the Westminster West fault (McWilliams and others, 2013). The youngest generation cleavage (S4) in the area is a cm 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, largely 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 (sheet 2). 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 Ammonoosuc fault (Walsh, in press), but sufficient data were not observed in this map area to demonstrate spatial correlation between kink bands and brittle faults. The youngest deformation is characterized by Mesozoic brittle faulting, kink bands, motion along the Ammonoosuc fault and smaller unnamed faults, possible re-activation of the Sumner Falls and Northey Hill fault zones, and subsequent jointing (sheet 2).

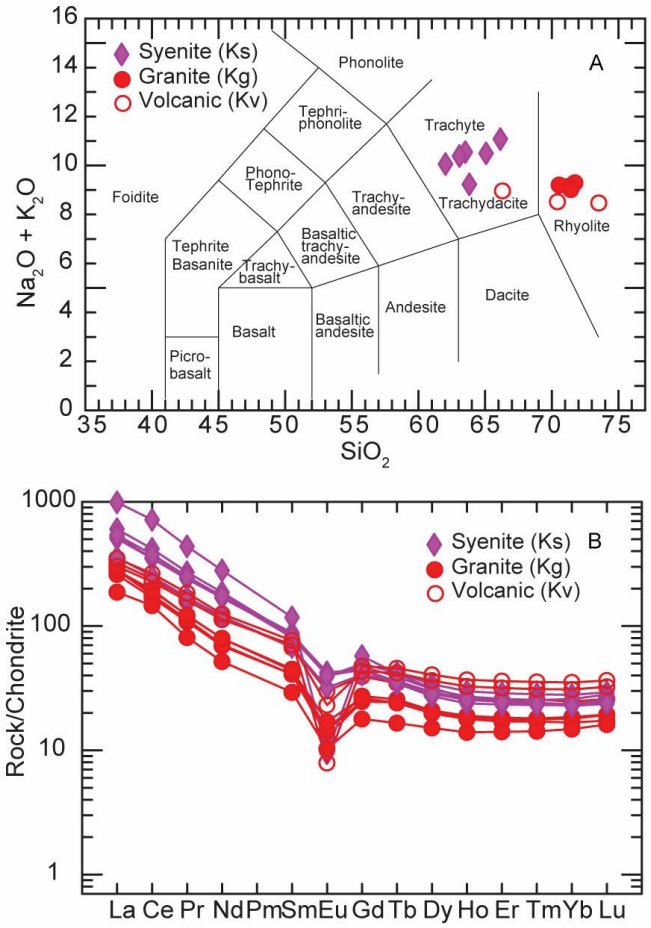
Rocks of the Mount Holly Complex in the core of the Chester dome may have reached hornblende-granulite facies metamorphism during the Mesoproterozoic Grenvillian orogenic events, and later experienced re-metamorphism at lower grades during the Ordovician Taconian and Devonian Acadian metamorphic events. Peak metamorphic conditions in the dome Chester during Paleozoic metamorphism reached staurolite-kyanite grade, but direct evidence of 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 NHS, and the western part of the CVT, but attained only greenschist facies in parts of the central CVT and NHS during the Acadian orogeny. We recognize no relict Taconian metamorphic mineral assemblages in the pre-Silurian rocks in this area, perhaps due to the thoroughness of recrystallization associated with the Acadian metamorphic overprint. The Monroe thrust sheet placed the NHS rocks over the CVT during an early Acadian F1 nappe-stage event prior to peak metamorphism that reached lower amphibolite facies conditions. The onset of doming occurred during F2 and which folded the Monroe thrust sheet, folded earlier isograds, and created the Meriden antiform and related structures. Doming continued as evidence by the deformation of D2 by D3 structures. Lower greenschist facies (Alleghanian) faults such as the Sumner Falls and Northey Hill fault 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 mica 40Ar/39Ar ages of ~380 and ~330 Ma in VT, and ~330 and ~270 in NH (Harrison and others, 1989; Kohn and others, 1992; Spear and others, 2008; McWilliams and others, 2013; McAleer and others, 2015). Additionally, in the vicinity of the Bald Mountain shear zone, 40Ar/39Ar data on muscovite show cooling ages of ~320 Ma from previous staurolite-grade assemblages and crystallization ages of ~247-423 Ma associated with new Ms growth and pseudomorphic replacement of staurolite, expanding ductile

deformation and down to the east normal extension in the area into the Triassic (McAleer and others, 2014, 2015). These ages suggest that the peak metamorphic conditions developed during the Acadian orogeny and retrograde greenschist facies metamorphism occurred during the Alleghanian. Apatite fission track data indicate that the Ammonoosuc fault was activate prior to about 100 Ma and experienced little to no re-activation in the Cretaceous, but other regionally significant older ductile faults such as the Northey Hill, experienced Late Cretaceous (~<80 Ma) re-activation (Roden-Tice and others, 2009). Recent data suggest some Cretaceous activity on regional brittle faults like the Grantham fault in the Springfield quadrangle to the south may have extended into the Cenozoic during the Paleocene (Schnalzer and others, 2015).

This report includes two color maps (sheets 1 and 2) and a database including contacts of bedrock geologic units, faults, outcrops, structural geologic information, and photographs. It supersedes a preliminary report compiled for the Vermont part of the map area by Walsh and others (1996a, b). The complete report is available online at: http://pubs.usgs.gov/SIM/xx/

Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Geochemical Plots



Geochemical plots of the main map units from the main stock of Mt. Ascutney. (A) Alkalies–silica plot after LeBas et al. (1986). (B) Rock/Chondrite normalized rare earth element diagram after Sun and McDonough (1989). Sample locations included in the GIS database.

Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

Geochemical Table

MapUnit	Ks	Kv	Kg	Kg	Ks	Ks	Ks	Kg	Kg	Ks	Kg	Ks	Kv	Kv
Sample	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	granite	granite	syenite	syenite	syenite with hornfels xenoliths	granite	granite	syenite	granite	syenite	volcanic	volcanic
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[2]O[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[2]O[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[2]O	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[2]O	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[2]O[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	99.47	98.19	99.2	99.54	99.17	98.57	98.05	98.72	99.73	98.19	98.25	98.28	97.99	98.73
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

Whole rock geochemistry by Actlabs, Acaster Ontario, Canada. Analyses by lithium metaborate/tetraborate fusion ICP whole rockfusion.

Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

References

Aleinikoff, J.N., Ratcliffe, N.M., and Walsh, G.J., 2011, Provisional zircon and monazite uranium-lead geochronology for selected rocks from Vermont: U.S. Geological Survey Open-File Report 2011-1309, 46 p., http://pubs.usgs.gov/of/2011/1309/.

Balk, R., and Kreiger, P., 1936, Devitrified felsite dikes from Ascutney Mountain, Vermont: American Mineralogist, v. 21, p. 516-522.

Billings, M.P., 1937, Regional metamorphism in the Littleton - Moosilauke area, New Hampshire: Geological Society of America Bulletin, v. 48, p. 463-566.

Billings, M.P., 1956, The geology of New Hampshire, Part II, bedrock geology: Concord, N.H., New Hampshire State Planning and Development Commission, 203 p., scale 1:250,000.

Boucot, A.J., MacDonald, G.J.F., Milton, C., and Thompson, J.B., Jr., 1958, Metamorphosed Middle Paleozoic fossils from central Massachusetts, eastern Vermont, and western New Hampshire: Geological Society of America Bulletin, v. 69, p. 855-870.

Boucot, A.J., and Thompson, J.B., Jr., 1963, Metamorphosed Silurian brachiopods from New Hampshire: Geological Society of America Bulletin, v. 74, p. 1313-1334.

Chapman, R.W., and Chapman, C.A., 1940, Cauldron subsidence at Ascutney Mountain, Vermont: Geological Society of America Bulletin, v. 51, p. 191-212.

Daly, R.A., 1903, Geology of Mount Ascutney, Vermont: U.S. Geological Survey Bulletin No. 209, 122 p.

Daniels, D.L., 1990, Magnetic and gravity expression of Cretaceous alkalic plutonic complexes at Cuttingsville and Mount Ascutney, Vermont: U.S. Geological Survey, Bulletin 1887-C, 8 p.

Foland, K.A., and Faul, H., 1977, Ages of the White Mountain intrusives- New Hampshire, Vermont, and Maine, USA: American Journal of Science, v. 277, p. 888-904.

Foland, K.A., Henderson, C.M.B., and Gleason, Jim, 1985, Petrogenesis of the magmatic complex At Mount Ascutney, Vermont, USA, I. Assimilation of crust by mafic magmas based on Sr and O isotopic and major element relationships: Contributions to Mineralogy and Petrology, v. 90, p. 331-345.

Hatch, N.L., Jr., 1988, New evidence for faulting along the "Monroe Line", eastern Vermont and westernmost New Hampshire: American Journal of Science, v. 288, no. I, p. 1-18.

Harrison, T.M., Spear, F.S., and Heizler, M., 1989. Geochronologic studies in central New England II: Post-Acadian hinged and differential uplift. Geology, v. 17, p. 185–189.

Kohn, M.J., Orange, D.L., Spear, F.S., Rumble, D., and Harrison, T.M., 1992. Pressure, temperature, and structural evolution of west-central New Hampshire: hot thrusts over cold basement: Journal of Petrology, v. 33, p. 521–556.

LeBas, M.J., LeMaitre, R.W., Streckeisen, A., Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali silica diagram: Journal of Petrology, v. 27, p. 745–750.

Lyons, J. B., Bothner, W. A., Moench, R. H., and Thompson, J. B., 1997, Bedrock geologic map of New

Hampshire: U.S. Geological Survey, scale 1:250,000.

McAleer, R.J., Kunk, M.J., Merschat, A.J., Valley, P.M., Walsh, G.J., and Wintsch, R.P., 2015, 40Ar/39Ar Constraints on the Paleozoic cooling history of southwest New Hampshire and adjacent Vermont: Geological Society of America Abstracts with Programs, v. 47, no. 3, p.42.

Macdonald, F.A., Ryan-Davis, J., Coish, R.A., Crowley, J.L., and Karabinos, P., 2014, A newly identified Gondwanan terrane in the northern Appalachian Mountains: Implications for the Taconic orogeny and closure of the Iapetus Ocean: Geology, v. 42, no. 6, p. 539–542, doi:10.1130/G35659.1

McHone, J.G., 1984, Mesozoic igneous rocks of northern New England and adjacent Québec: Summary, description of map, and bibliography of data sources: Geological Society of America Map and Chart Series MC-49, scale 1:690,000.

McHone, J.G., and McHone, N.W., 2012, Mesozoic dikes and tectonic features in the central Connecticut River valley, Vermont and New Hampshire, in Thompson, P.J., and Thompson, T.B., editors, Guidebook to field trips in western New Hampshire and adjacent Vermont and

Massachusetts, 104th New England Intercollegiate Geological Conference, Mount Sunapee, New Hampshire, p. C2-1 – C2-18.

McWilliams, C.K., Kunk, M.J., Wintsch, R.P., and Bish, D.L., 2013, Determining ages of multiple muscovite-bearing foliations in phyllonites using the 40Ar/39Ar step heating method: Applications to the Alleghanian orogeny in central New England: American Journal of Science, v. 313, p. 996–1016, DOI 10.2475/10.2013.02

Nielson, D.L., 1973, Silica diffusion at Ascutney Mountain, Vermont: Contributions to Mineralogy and Petrology, v. 40, p. 141-148.

Rankin, D.W., Coish, R.A., Tucker, R.D., Peng, Z.X., Wilson, S.A., and Rouff, A.A., 2007, Silurian extension in the upper Connecticut Valley, United States and the origin of middle Paleozoic basins in the Québec embayment: American Journal of Science, v. 307, p. 216–264.

Rankin, D.W., Tucker, R.D., and Amelin, Yuri, 2013, Reevaluation of the Piermont-Frontenac allochthon in the Upper Connecticut Valley: Restoration of a coherent Boundary Mountains–Bronson Hill stratigraphic sequence: Geological Society of America Bulletin, v. 125, no. 5-6, p. 998-1024, doi:10.1130/B30590.1

Ratcliffe, N.M., 1995a, Digital bedrock geologic map of the Cavendish quadrangle, Vermont: U.S. Geological Survey Open-File Report 95–203, 2 pls., scale 1:24,000

Ratcliffe, N.M., 1995b, Digital bedrock geologic map of the Chester quadrangle, Vermont: U.S. Geological Survey Open-File Report 95–576, 2 pls., scale 1:24,000

Ratcliffe, N.M., 2000a, Bedrock geologic map of the Cavendish quadrangle, Windsor County, Vermont: U.S. Geological Survey Geologic Quadrangle Map GQ–1773, 1 pl., scale 1:24,000, includes pamphlet, 19 p.

Ratcliffe, N.M., 2000b, Bedrock geologic map of the Chester quadrangle, Windsor County, Vermont: U. S. Geological Survey Geologic Investigations Series Map I–2598, 1 pl., scale 1:24,000, includes pamphlet, 16 p.

Ratcliffe, N.M., Aleinikoff, J.N., Burton, W.C., and Karabinos, P., 1991, Trondhjemitic, 1.35-1.31 Ga

gneisses of the Mount Holly Complex of Vermont: evidence for an Elzevirian event in the Grenville Basement of the United States Appalachians: Canadian Journal of Earth Science, v. 28, p. 77-93.

Ratcliffe, N.M., Stanley, R.S., Gale, M.H., Thompson, P.J., and Walsh, G.J., 2011, Bedrock geologic map of Vermont: U.S. Geological Survey Scientific Investigations Map 3184, 3 sheets, scale 1:100,000, http://pubs.usgs.gov/sim/3184/

Schnalzer, K.M., Biss, J.S., IV, Roden-Tice, M., Walsh, G.J., McFadden, R.R., and Valley, P.M., 2015, Displacement history of the Grantham fault in southwest New Hampshire constrained by apatite fission-track ages: Geological Society of America Abstracts with Programs, v. 47, no. 3, p. 93.

Schneiderman, J.S., 1989, The Ascutney Mountain breccia: field and petrologic evidence for an overlapping relationship between Vermont sequence and New Hampshire sequence rocks: American Journal of Science, v. 289, p. 771-811.

Sun, S.S., and McDonough, F., 1989, Chemical and isotopic systematic of oceanic basalts; implications for mantle composition and processes: Geological Society of London, v. 42, p. 313–345.

Thompson, J.B., Jr., McLelland, Jim, and Rankin, D.W., 1990, Simplified geologic map of the Glens Falls 1 degree x 2 degrees quadrangle, New York, Vermont, New Hampshire: U.S. Geological Survey, Miscellaneous Field Studies Map MF-2073, scale 1:250,000.

Thompson, J.B., Robinson, Peter, Clifford, T.N., and Trask, N.J., 1968, Nappes and gneiss domes in west-central New England: in Zen, E.-A., White, W.S., Hadley, J.B., and Thompson, J. B. Jr., editors, Studies of Appalachian Geology, Northern and Maritime, John Wiley, New York, p. 203–218.

Thompson, J.B., Jr., Bothner, W.A., Robinson, Peter, Isachsen, Y.W., and Klitgord, K.D., 1993, Geological Society of America, Centennial Continent-Ocean Transect, No. 17, E-1, Adirondacks to Georges Bank, 55 p., scale 1:500,000.

Valley, P.M., and Walsh, G.J., 2013, New U-Pb zircon ages from the Bronson Hill anticlinorium, west-central New Hampshire: Geological Society of America, Abstracts with Programs, v. 45, no. 1, p. 108.

Valley, P.M., Walsh, G.J., And Mcaleer, R.J., 2015, New U-Pb zircon ages from the Bronson Hill arc, west-central New Hampshire: Geological Society of America Abstracts with Programs, v. 47, no. 3, p.41.

Walsh, G.J., in press, 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 xxx, 2 sheets, scale 1:24,000.

Walsh, G.J., Armstrong, T.R., and Ratcliffe, N.M., 1996a, Preliminary bedrock geologic map of the Vermont part of the 7.5 x 15 minute Mount Ascutney and Springfield quadrangles, Windsor County, Vermont: U.S. Geological Survey Open File Report 96-719, 38 p., scale 1:24,000.

Walsh, G.J., Armstrong, T.R., and Ratcliffe, N.M., 1996b, Digital bedrock geologic map of the Vermont part of the 7.5 x 15 minute Mount Ascutney and Springfield quadrangles, Vermont: U.S. Geological Survey Open File Report 96-733, scale 1:24,000.

Extracted from: (*GRI Source Map ID 76010*) (Mt. Ascutney 7.5 x 15 Minute Quad).

GRI Digital Data Credits

This document was developed and completed by James Winter (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara (Colorado State University).

The information in this document was compiled from GRI source maps, and intended to accompany the digital geologic-GIS map and other digital data for Saint-Gaudens National Historic Site, New Hampshire and Vermont (SAGA) developed by Jim Chappell (Colorado State University), James Winter and Stephanie O'Meara (see the GRI Digital Map and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps

GRI finalization by Jim Chappell (Colorado State University).

GRI program coordination and scoping provided by Bruce Heise (NPS GRD, Lakewood, Colorado).