U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in Cooperation with the
VERMONT GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 3111
Explanatory pamphlet accompanies map

CORRELATION OF MAP UNITS

IGNEOUS AND METASOMATIC ROCKS

Lamprophyre or diabase dike — CRETACEOUS
Quartz vein — Dq
Granitic dike — Dg

ROCKS OF THE CONNECTICUT VALLEY-GASPÉ SYNCLINORIUM

DEVONIAN

Gile Mountain Formation: Dgmcp, Dgm, Dgml
Waits River Formation: DSwt, DSw, DSwq, DSwg, DSwl$_2$, DSwl$_1$
Northfield Formation: DSn
Shaw Mountain Formation: Ssg, Ss

DEVONIAN AND SILURIAN

Unconformity and Dog River fault zone
Richardson Memorial Contact

SILURIAN

ROCKS OF PRE-SILURIAN AGE

SILURIAN(?) TO ORDOVICIAN(?)

SOdg — Metadiabase and greenstone dikes or sills

ORDOVICIAN

Cram Hill Formation: Ochr, Ochi, Ochq, Ochc

ORDOVICIAN AND CAMBRIAN

Moretown Formation: Dumpling Hill belt (OCmpb, OCmsr, OCmdh); Wrightsville belt (OCmq, OCmbp, OCmg, OCm, OCmw); Shady Hill fault

DESCRIPTION OF MAP UNITS

[Major minerals listed in order of increasing abundance]

IGNEOUS AND METASOMATIC ROCKS

Lamprophyre or diabase dike (Cretaceous)—Aphanitic, very dark gray to black, brown- and rusty-weathering lamprophyre or diabase dikes; location shown by strike and dip symbol. Dikes range in thickness from 0.4 to 2 m and locally contain phenocrysts of biotite, amphibole, pyroxene, and olivine. Dikes may show zoning and chilled margins and locally contain amygdules filled with dolomite or calcite. Wall rocks generally contain subparallel joint sets. Dikes are unfoliated but may be jointed

Quartz vein (Devonian)—Map-scale quartz veins locally measure as much as 15 to 20 m thick, north of Martin Brook in Williamstown and on the northern side of Irish Hill in Berlin. Other mapped veins are approximately 3 m thick or less, and their sizes are exaggerated on the map to show the locations. Conspicuous outcrop-scale tabular quartz veins are shown by strike and dip symbols and range in thickness from 3 cm to 3 m. Veins contain accessory muscovite and ankerite. Large, irregular quartz veins as much as several meters across are shown with point symbols. Smaller, irregularly shaped quartz veins are ubiquitous and have not been mapped separately

Granitic dike (Devonian)—Fine- to medium-grained, moderately to weakly foliated or unfoliated, very light gray to white- or tan-weathering trondhjemite, granodiorite, or muscovite-biotite granitic dikes. The rock contains variable amounts of muscovite, biotite, K-feldspar, quartz, and plagioclase. Feldspar compositions primarily include microcline and oligoclase (Chayes, 1952; Cady, 1956; Murthy, 1957). Rocks contain accessory carbonate, sphene, zircon, epidote, clinozoisite, chlorite, and pyrite. Thin dikes and the margins of thick dikes and sills exhibit S_3 foliation (Acadian S_3); the interiors of large bodies may be unfoliated. Dikes occur primarily in two places: (1) near the village of Adamant where Cady (1956) identified the type locality of the Adamant Granite in Calais and (2) along strike to the southwest near Crosstown Road in Berlin. Abandoned quarries are found in both areas. The dikes cut bedding and are generally parallel to the steep S_2 foliation (Acadian S_2). Outcrop-scale dikes (0.25 to 3 m thick) occur throughout the eastern part of the area and are shown by strike and dip symbols. Larger map-scale dikes are as much as several hundred meters thick. Thin dikes are locally trondhjemitic to granodioritic, are locally porphyritic with microcline phenocrysts ≤0.5 cm, and contain secondary pyrite porphyroblasts ≤0.5 cm. Country rock may be brecciated along the margins of the dikes

ROCKS OF THE CONNECTICUT VALLEY-GASPÉ SYNCLINORIUM

Gile Mountain Formation (Devonian)

Dgm — Phyllite and quartzite—Interbedded dark-gray to silvery-gray quartz-muscovite phyllite or fine-grained schist and micaceous or feldspathic quartzite, locally sulfidic and rusty weathering. Quartzite consists approximately of 80 percent quartz, 10 percent plagioclase and biotite, and accessory muscovite, chlorite, and garnet. Graded beds, locally present (10–30 cm thick), most of which are overturned to the southeast. The schist generally contains less than 20 percent biotite, chlorite, and plagioclase and accessory porphyroblasts of garnet. Accessory minerals include pyrite, rutile, ilmenite, hematite, magnetite, zircon, apatite, tourmaline, and graphite

Dgmcp — Calcareous phyllite—Dark-gray, dark-brown-weathering calcite-chlorite-plagioclase-quartz-muscovite phyllite occurs in layers, 30 to 40 cm thick within Dgm. Rock is similar to thin, unmapped layers within the Waits River Formation. The size of the unit is exaggerated on the map to show its location

Dgml — Limestone—Bluish-gray, brown-weathering, impure, siliceous muscovite-quartz-calcite limestone or marble; occurs as a single 50-cm-thick layer within Dgm along McGlynn Road (name not shown on map) in Williamstown. Rock is similar to limestone within the Waits River Formation. The size of the unit is exaggerated on the map to show its location

Waits River Formation (Devonian and Silurian)—Units not necessarily in stratigraphic order

DSwt — Thickly bedded limestone and phyllite—Interbedded dark-gray to silvery-gray, locally sulfidic and rusty-weathering, chlorite-plagioclase-quartz-muscovite phyllite, slate, or schist and brown-weathering, bluish-gray to gray, impure, siliceous limestone or marble. 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. Quartz may occur as millimeter-scale clasts interpreted as detrital, matrix-supported grains. Generally the pelites are slaty to phyllitic in the biotite zone and schistose in the garnet zone. Other accessory minerals in the pelites include pyrite, calcite, rutile, ilmenite, hematite, zircon, monazite, apatite, tourmaline, graphite, xenotime, and possible thorite. 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 1.0 to 5.0 m thick and locally measure as much as 9.0 m thick. Phyllite beds generally measure 0.2 to 1.3 m thick. Contains rare, thin beds (≤20 cm) of light-gray quartzite similar to **DSwq**. Bedding is clearly visible as the contacts between limestone and phyllite. Bedding within the phyllite is difficult to see but is locally indicated by concentrations of sulfides, the most readily identifiable of which is pyrite. Map unit is similar in composition to **DSwl$_1$** and **DSwl$_2$**, but bedding in the phyllites and especially in the limestones is appreciably thicker in **DSwt**

DSwl$_1$, **DSwl$_2$** — Thinly bedded limestone and phyllite—Interbedded dark-gray to silvery-gray, locally sulfidic and rusty-weathering, chlorite-plagioclase-quartz-muscovite phyllite, slate, or schist and brown-weathering, bluish-gray, impure, siliceous limestone or marble. The phyllite contains accessory biotite and garnet porphyroblasts in the garnet zone and rare biotite porphyroblasts in the biotite zone. Composition of limestones and phyllites similar to **DSwt**. Contains rare, thin beds (≤20 cm) of light-gray quartzite similar to **DSwq**. Limestone beds generally measure 0.2 to 3.0 m thick and locally measure as much as 5.0 m thick. Phyllite beds generally measure 0.2 to 0.5 m thick. Bedding is clearly visible as the contacts between limestone and phyllite. Bedding within the phyllite is difficult to see but is locally indicated by concentrations of rusty-weathering pyrite. **DSwl$_1$** occurs at the base and **DSwl$_2$** occurs at the top of the Waits River Formation, but the rocks are lithologically similar

DSw, **DSw$_1$**, **DSw$_2$** — Phyllite—Dark-gray to silvery-gray, locally sulfidic and rusty-weathering chlorite-quartz-muscovite slate, phyllite, slaty phyllite, or fine-grained schist. Contains accessory biotite and garnet porphyroblasts in the garnet zone and rare biotite porphyroblasts in the biotite zone. Contains less than 10 percent plagioclase. Accessory minerals include pyrite, calcite, rutile, ilmenite, zircon, monazite, apatite, tourmaline, graphite, and xenotime. Bedding is difficult to see but is locally indicated by concentrations of sulfides. Where visible, bedding is generally 0.2 to 0.5 m thick. **DSw$_1$** occurs within **DSwl$_1$**, and **DSw$_2$** generally occurs between **DSwl$_2$** and **DSwt**. Rocks mapped simply as "**DSw**" are interpreted as lenses of phyllite due to facies changes at several places within the Waits River Formation. Lithologically, these units are similar to the phyllite in the **DSwt**, **DSw$_1$**, and **DSw$_2$** units

DSwg — Garnetiferous phyllite—Dark-gray, non-rusty-weathering garnet-chlorite-quartz-muscovite phyllite with distinctive, abundant, small (0.1–2.0 mm), euhedral garnet porphyroblasts or chlorite pseudomorphs after garnet. Contains less than 10 percent plagioclase. Accessory minerals include pyrite, calcite, rutile, ilmenite, zircon, monazite, apatite, tourmaline, graphite, and xenotime. Unit occurs in the eastern limit of the Acadian garnet isograd

DSwq — Quartzite—Light-gray, locally rusty-weathering and sulfidic, micaceous to feldspathic to calcareous quartzite. Rock contains 75 percent or more quartz, and 5 to 10 percent muscovite, plagioclase, and (or) calcite. Accessory minerals include pyrite, graphite, tourmaline, and zircon or monazite. The quartzite consists of multiple or individual beds, 0.3 to 3 m thick. The quartzite is locally interlayered with dark-gray quartz-muscovite phyllite. The size of the unit is exaggerated on the map to show its location. Rare, thin, unmapped quartzite also occurs within **DSwt**, **DSwl$_1$**, and **DSwl$_2$**

Northfield Formation (Devonian? and Silurian)

DSn — Phyllite—Dark-gray, locally rusty-weathering and sulfidic, quartz-muscovite phyllite or slate. Bedding in the phyllite, although rarely visible in natural outcrops and more visible in roadcuts, generally ranges from 10 to 30 cm thick. Thin, micaceous quartzite and brown-weathering calcareous phyllite beds ≤20 cm thick locally occur in the Northfield Formation and define bedding, where present. Thin (≤10 cm), impure limestone beds are very rare but increase in abundance at the eastern contact with the Waits River Formation. The contact with the Waits River Formation is mapped on the first occurrence of abundant interbedded limestone

DSnc — Conglomerate—Dark-gray, matrix-supported conglomerate. Poorly exposed at a single outcrop along the Dog River in Berlin, near the base of the Northfield Formation. Matrix consists of dark-gray phyllite similar to the phyllite of the Northfield Formation (**DSn**). Clasts consist of tabular, tectonically elongated rock fragments of light-gray to white ankerite-spotted phyllite and quartzite measuring as much as approximately 10 cm thick by 50 cm long. Conglomerate is intraformational within the Northfield Formation near its base and approximately 2 to 3 m thick. The size of the unit is exaggerated on the map to show its location

Shaw Mountain Formation (Silurian)

Ssg — Ankeritic greenstone and green schist—A heterogeneous unit of interlayered rocks consisting largely of ankeritic greenstone and green calcareous quartz-chlorite-albite schist. Greenstone is a light- to dark-green, actinolite-epidote-quartz-chlorite-albite rock, locally with conspicuous epidote as laminae and elliptical pods flattened parallel to the dominant foliation. Greenstone locally contains albite porphyroblasts and (or) plagioclase phenocrysts. Contains interlayered green and gray phyllite and gray to dark-gray carbonaceous phyllite; gray to gray-green, punky-weathering, calcareous quartz-albite-chlorite-calcite (or ankerite) schist or granofels; silvery-gray, cream-weathering muscovite-quartz-plagioclase schist and granofels; pale-gray to tan, cream- to tan-weathering, ankerite-spotted micaceous quartzite and small-pebble conglomerate. Contains conglomerate lenses mapped separately as **Ss**. The contact with the Cram Hill Formation is gradational and marked by interlayered gray to dark-gray carbonaceous phyllite within **Ssg** near the contact. The contact with the Northfield Formation is sharp. Unit interpreted as interlayered metavolcanic and volcaniclastic rock

Ss — Conglomerate—Quartz-pebble and quartz-cobble conglomerate. Slightly to very rusty weathering and friable conglomerate composed dominantly of rounded pebbles and cobbles of medium- to coarse-grained vein quartz and rare metamorphic rock fragments consisting of elongate pieces of gray granofels. Contains interlayered green and gray phyllite and punky-weathering, calcareous quartz-albite-chlorite-calcite schist or granofels. Clast-supported zones in the conglomerate locally grade into phyllite or granofels. Locally very friable and sulfidic with abundant disarticulated quartz veins. Occurs as thin, discontinuous lenses, as much as 5 m thick, entirely within **Ssg**. Quartz pebbles are relatively undeformed in the northeastern part of the field area and are unlike the stretched and elongated clasts in the conglomerate of the Northfield Formation (**DSnc**) in the Dog River fault zone to the south

ROCKS OF PRE-SILURIAN AGE

SOdg — **Metadiabase and greenstone dikes or sills (Silurian? to Ordovician?)**—Grayish-green to green, fine- to medium-grained, massive, weakly foliated greenstone and coarse-grained, massive, weakly foliated metadiabase. Due to the massive structure, outcrops weather to rounded bulbous shapes. Major minerals include quartz, chlorite, epidote, actinolite, and plagioclase. Locally contains plagioclase phenocrysts and relict diabase texture where plagioclase content exceeds and encloses semi-rectangular masses of epidote-actinolite that probably originated as pyroxene. Fresh surfaces locally effervesce in HCl due to the presence of secondary calcite. The intrusions are approximately 0.3 to 3 m wide. Relict chilled margins are common on the thicker intrusions. Contacts with the adjacent rocks are usually concordant, subparallel to the dominant S_2 foliation but locally exhibit low- to high-angle discordance with the dominant S_2 foliation. The dikes predate the S_3 foliation. The dikes are discontinuous, and individual bodies could not be traced very far along strike. Dikes or sills occur as fine- to medium-grained greenstone both with and without diabase texture. Whole-rock geochemistry from samples in the Montpelier quadrangle shows basaltic compositions (Twelker, 2004). These dikes were observed only in the Wrightsville belt. The intrusions are shown on the map as small elongate bodies. The size of the dikes is exaggerated on the map to show the location. Point symbols show locations on the map where greenstone and (or) metadiabase of uncertain origin (volcanic or intrusive) were seen but not mapped separately

Cram Hill Formation (Ordovician)—Contains greenstone layers and metadiabase or greenstone dikes and sills

Ochr — Carbonaceous phyllite—Gray to dark-gray or black carbonaceous phyllite locally interlayered with silvery-gray phyllite, feldspathic quartzite, and greenstone. Rusty-weathering, gray to dark-gray or black chlorite-plagioclase-quartz-muscovite phyllite that is locally carbonaceous (±graphite). Carbonaceous phyllite is locally pyritiferous. Locally interlayered with silvery-gray and grayish-green phyllite and massive, gray, granular feldspathic quartzite (usually boudinaged). Rare, pearly-white-weathering quartz-feldspar granofels interpreted as metatuffs occur in the northeastern part of the map on the eastern side of this formation. Punky-weathering, silvery-green ankerite-calcite-chlorite-albite schist to ankeritic greenstone with calcite-ankerite porphyroblasts occurs locally in the eastern part of the Cram Hill Formation; because this lithology is similar to highly weathered ankeritic greenstones in the Cram Hill and Moretown Formations, we place the greenstone in the pre-Silurian section and not in the Shaw Mountain Formation as did Cady (1956)

Ochq — Quartzite—Massive to well-foliated, light-gray to dark-gray or gray banded quartzite; may be feldspathic or micaceous due to the presence of plagioclase and (or) muscovite. Contains trace carbonate, graphite, apatite, tourmaline, and opaques. Locally contains rusty-weathering porphyroblasts of ankerite or octahedra of magnetite. Occurs as disarticulated lenses or boudins or as layers as much as several meters thick. Thin, unmapped similar quartzites occur throughout the Cram Hill Formation

Ochc — Phyllite and granofels with coticule—Black-weathering, gray and green chlorite-plagioclase-quartz-muscovite phyllite and granofels with thin millimeter-scale ribbons of disarticulated coticule (fine-grained quartz-spessartine rock); contains greenstone layers, some with phenocrysts of plagioclase. Coticule layers locally form rootless isoclinal folds that intersect on foliation surfaces as downdip lineations parallel to these fold axes. Thin coticule layers stand out in relief as resistant ridges

Ochi — Interlayered phyllite, quartzite, and granofels—Interlayered grayish-green to silvery-gray chlorite-plagioclase-quartz-muscovite phyllite with porphyroblasts of magnetite; micaceous quartzite with porphyroblasts of ankerite; grayish-green granofels; dark-gray phyllite; rare dark-gray to black carbonaceous phyllite; minor quartz-pebble conglomerate; and greenstone. This unit is transitional in composition between the **Ochr** unit of the Cram Hill and the **OCm** unit of the Moretown Formation

Moretown Formation in the Wrightsville belt (Ordovician and Cambrian)—Contains greenstone layers and metadiabase and greenstone dikes or sills; locally mapped separately or shown with symbols

OCm, **OCmbp** — Phyllite, granofels, and "pinstripe" granofels—Interlayered light-green and silvery-green to grayish-green chlorite-plagioclase-quartz-muscovite phyllite, schist, and chlorite-muscovite-plagioclase-quartz granofels and "pinstripe" granofels; locally contains small-pebble conglomerate similar to **OCmq**. Accessory minerals include biotite, opaques, magnetite, calcite, apatite, and tourmaline. In the central part of the map between Montpelier and Middlesex, the unit is studded with magnetite. Locally contains massive, gray to light-gray, granular quartzites similar to **OCmq**. The characteristic "pinstripe" fabric is defined by alternating millimeter-scale layers of albite-quartz and chlorite-muscovite. Punky-brown-weathering, silvery-green to light-green calcite-chlorite-plagioclase-quartz schist and granofels with porphyroblasts of calcite and muscovite (≤2 mm) are locally present in the eastern part of the formation. Contains rare, dark-gray to black, rusty-weathering carbonaceous quartz-muscovite phyllite (**OCmbp**) mapped separately at one place along the Dog River

OCmq — Feldspathic quartzite and small-pebble conglomerate—Gray to grayish-green, fine- to medium-grained micaceous or feldspathic quartzite and muscovite-chlorite-plagioclase-quartz small-pebble conglomerate with matrix-supported clasts generally as much as 0.5 mm, and rarely as much as 1 cm, composed chiefly of feldspar and blue quartz. Occurs as layers, 0.5 to 2 m thick within **OCm**

OCmg — Greenstone—Green to grayish-green, fine- to medium-grained, weakly to moderately foliated, locally layered actinolite-quartz-sphene-calcite-chlorite-plagioclase gneiss or "greenstone" and locally massive, unfoliated to weakly foliated, green to grayish-green quartz-sphene-calcite-amphibole-chlorite-plagioclase greenstone. Massive rocks weather to rounded bulbous outcrops. The greenstones are interpreted as metamorphosed mafic extrusive volcanic to volcaniclastic rocks or possibly intrusive rocks. May contain thin (<20 cm) metadiabase layers that resemble metadiabase dikes mapped separately (**SOdg**). In the field, it is not always possible to separate the greenstone from the metadiabase or see features that would conclusively demonstrate extrusive versus intrusive origin, and for this reason we map **OCmg** simply as greenstone. Greenstones contain more calcite and chlorite and are more strongly foliated than metadiabases. Where present, plagioclase clasts, interpreted as relict phenocrysts, locally increase in abundance away from the contacts with surrounding rocks. Fresh surfaces weakly effervesce in dilute HCl due to the presence of secondary calcite. Trace element geochemistry shows the sampled greenstones have tholeiitic basalt signatures (Twelker, 2004). These mafic rocks occur only in the Wrightsville belt

OCmw — Interlayered green and dark-gray phyllite—Interlayered gray and green phyllite; quartzite; rusty-weathering, dark-gray to black carbonaceous phyllite; and granofels; similar to **OCmw** of the adjacent Wrightsville belt. Grayish-green rocks are similar to **OCmb** in this belt and **OCm** in the adjacent Wrightsville belt, and carbonaceous rocks are similar to **OCmdh** in this belt and **OCmbp** in the Wrightsville belt

OCmpb — Phyllite, granofels, and "pinstripe" granofels—Interlayered green phyllite; granofels; green "pinstripe" granofels; quartzite; and quartz-pebble conglomerate; similar to **OCm** in the Wrightsville belt

OCmdh — Carbonaceous phyllite and quartzite—Dark- to medium-gray and black phyllite; minor granofels; laminated, tan-weathering quartzite; vitreous quartzite; and rare quartz-pebble conglomerate. Dark-gray and black phyllite is carbonaceous, rusty weathering, and locally pyritiferous. Bedding and a relict S_1 layer-parallel schistosity are preserved in more massive granofels and quartzites, although they are commonly transposed in the plane of S_2. Bedding and subparallel S_1 at high angles to the S_2 foliation is exposed near the summit of Dumpling Hill where F_2 and later folds plunge to the north. A typical section is exposed on the eastern flank of Dumpling Hill, southwest of Worcester where 1.0- to 1.5-m-thick beds of dark-gray phyllite are interbedded with tan-weathering, white- and gray-laminated quartzite. A 1.5-m-thick bed of quartz-pebble conglomerate occurs near the summit near the contact with green granofels. Quartzite-rich horizons in this unit compose topographically high areas such as Dumpling Hill

OCmsr — Interlayered green and dark-gray phyllite—Interlayered gray and green phyllite; quartzite; rusty-weathering, dark-gray to black carbonaceous phyllite; and granofels; similar to **OCmw** of the adjacent Wrightsville belt. Grayish-green rocks are similar to **OCmpb** in this belt and **OCm** in the adjacent Wrightsville belt, and carbonaceous rocks are similar to **OCmdh** in this belt and **OCmbp** in the Wrightsville belt

OCmcg — Greenstone—Green to grayish-green, fine- to medium-grained, weakly to moderately foliated, locally layered actinolite-quartz-sphene-calcite-chlorite-plagioclase gneiss or "greenstone" and locally massive, unfoliated to weakly foliated, green to grayish-green quartz-sphene-calcite-amphibole-chlorite-plagioclase greenstone. Massive rocks weather to rounded bulbous outcrops. The greenstones are interpreted as metamorphosed mafic extrusive volcanic to volcaniclastic rocks or possibly intrusive rocks. May contain thin (<20 cm) metadiabase layers that resemble metadiabase dikes mapped separately (**SOdg**). In the field, it is not always possible to separate the greenstone from the metadiabase or see features that would conclusively demonstrate extrusive versus intrusive origin, and for this reason we map **OCmg** simply as greenstone. Greenstones contain more calcite and chlorite and are more strongly foliated than metadiabases. Where present, plagioclase clasts, interpreted as relict phenocrysts, locally increase in abundance away from the contacts with surrounding rocks. Fresh surfaces weakly effervesce in dilute HCl due to the presence of secondary calcite. Trace element geochemistry shows the sampled greenstones have tholeiitic basalt signatures (Twelker, 2004). These mafic rocks occur only in the Wrightsville belt

OCmw — Interlayered green and dark-gray phyllite—Interlayered gray and green phyllite; quartzite; rusty-weathering, dark-gray to black carbonaceous phyllite; and granofels; similar to **OCmw** of the adjacent Wrightsville belt. Grayish-green rocks are similar to **OCmb** in this belt and **OCm** in the adjacent Wrightsville belt, and carbonaceous rocks are similar to **OCmdh** in this belt and **OCmbp** in the Wrightsville belt

Moretown Formation in the Dumpling Hill belt (Ordovician and Cambrian)—Does not contain greenstone layers or metadiabase or greenstone dikes or sills

OCmsr — Interlayered green and dark-gray phyllite—Interlayered gray and green phyllite; quartzite; rusty-weathering, dark-gray to black carbonaceous phyllite; and granofels; similar to **OCmw** of the adjacent Wrightsville belt. Grayish-green rocks are similar to **OCmpb** in this belt and **OCm** in the adjacent Wrightsville belt, and carbonaceous rocks are similar to **OCmdh** in this belt and **OCmbp** in the Wrightsville belt

OCmpb — Phyllite, granofels, and "pinstripe" granofels—Interlayered green phyllite; granofels; green "pinstripe" granofels; quartzite; and quartz-pebble conglomerate; similar to **OCm** in the Wrightsville belt

OCmdh — Carbonaceous phyllite and quartzite—Dark- to medium-gray and black phyllite; minor granofels; laminated, tan-weathering quartzite; vitreous quartzite; and rare quartz-pebble conglomerate. Dark-gray and black phyllite is carbonaceous, rusty weathering, and locally pyritiferous. Bedding and a relict S_1 layer-parallel schistosity are preserved in more massive granofels and quartzites, although they are commonly transposed in the plane of S_2. Bedding and subparallel S_1 at high angles to the S_2 foliation is exposed near the summit of Dumpling Hill where F_2 and later folds plunge to the north. A typical section is exposed on the eastern flank of Dumpling Hill, southwest of Worcester where 1.0- to 1.5-m-thick beds of dark-gray phyllite are interbedded with tan-weathering, white- and gray-laminated quartzite. A 1.5-m-thick bed of quartz-pebble conglomerate occurs near the summit near the contact with green granofels. Quartzite-rich horizons in this unit compose topographically high areas such as Dumpling Hill

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

[Dotted where concealed by water]

Overturned conjectural thrust fault—Parallel to regional S_2 foliation in the Shady Hill fault; sawteeth point in direction of dip, bar on upper plate

Reverse fault—Parallel to regional S_3 foliation in Dog River fault zone; U, upthrown side; D, downthrown side

FOLDS

[Arrow, where present, shows direction of plunge]

Inferred axial trace of F_1 fold in Dumpling Hill belt (Taconian)—Box shows dip direction of axial surface

Inferred axial trace of F_2 fold (Taconian)—Box shows dip direction of axial surface

Overturned F_3 syncline in Silurian and rocks (Acadian F_1)

Overturned F_3 anticline in Silurian and Devonian rocks (Acadian F_1)

Upright F_4 antiform in Silurian and Devonian rocks (Acadian F_2)

Upright F_4 synform in Silurian and Devonian rocks (Acadian F_2)

Strike and dip of axial surface of minor fold

Isoclinal F_2 fold parallel to S_2 foliation
70 Inclined
Vertical
F_3 fold parallel to S_3 foliation
76 Inclined
Vertical
F_4 fold parallel to S_4 cleavage
61 Inclined
Vertical

PLANAR FEATURES

[Symbols may be combined; point of intersection shows location of measurement. For foliation symbols, see table 1 (in accompanying pamphlet) for regional correlation of deformational fabrics]

Strike and dip of bedding—Ball indicates top of beds known from graded beds
68 Inclined
Vertical
62 Inclined, overturned
41 Inclined, highly deformed

Strike and dip of lamprophyre or diabase dike (Cretaceous)
64 Inclined
Vertical

Strike and dip of granitic dike (Devonian)
69 Inclined
Vertical

Strike and dip of quartz vein
76 Inclined
Vertical
Steeply dipping; dip uncertain

Strike and dip of outcrop-scale brittle fault
61 Inclined

Strike and dip of deformed S_1 or S_2 schistosity in pre-Silurian rocks

Strike and dip of dominant foliation in pre-Silurian rocks—Not age specific but largely S_2, or S_2 overprinted and parallel to S_3
70 Inclined
Vertical

Strike and dip of S_3 schistosity or cleavage (Acadian S_1) parallel to bedding in Silurian and Devonian rocks
60 Inclined
Vertical

Strike and dip of S_3 schistosity or cleavage (Acadian S_1)
65 Inclined
Vertical

Strike and dip of S_4 cleavage (Acadian S_2)
66 Inclined
Vertical

Strike and dip of S_5 cleavage (Acadian S_3)
63 Inclined

LINEAR FEATURES

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

Bearing and plunge of deformed mineral aggregate lineation in pre-Silurian rocks (L_2 or older)

Bearing and plunge of L_2 mineral aggregate lineation or mineral aggregate lineation of uncertain age (L_2 or L_3) in the plane of dominant foliation in pre-Silurian rocks

Bearing and plunge of L_3 cleavage-bedding intersection lineation, S_2–S_3 intersection lineation, mineral aggregate lineation, or stretched-pebble lineation

Bearing and plunge of L_4 crenulation or intersection lineation—Also occurs as an aligned biotite aggregate lineation or aligned quartz pressure shadows around garnet in the garnet zone

Bearing and plunge of F_2 fold axis in pre-Silurian rocks

Bearing and plunge of F_3 fold axis

Bearing and plunge of F_4 fold axis

Bearing and plunge of F_5 fold axis or crenulation

Slickensides on brittle fault

OTHER FEATURES

Abandoned quarry

Active quarry

Location of conspicuous garnet porphyroblasts in the eastern Waits River Formation

Garnet / Biotite — **Metamorphic isograd (Acadian)**

Mafic rock localities in the Wrightsville belt—Shows locations where greenstone and (or) metadiabase of uncertain origin (volcanic or intrusive) were seen but not mapped as separate units

Greenstone and metadiabase sample locality from Twelker (2004)

Greenstone

Greenstone and metadiabase

Metadiabase

Spring

14300 — **Four fossil localities in the Waits River Formation**—No. 7 locality from Cady (1950); three U.S. National Museum localities from Hueber and others (1990)

Location of irregularly shaped quartz vein

Site of photograph—Tip of arrow at point of observation; number keyed to figure in explanatory pamphlet

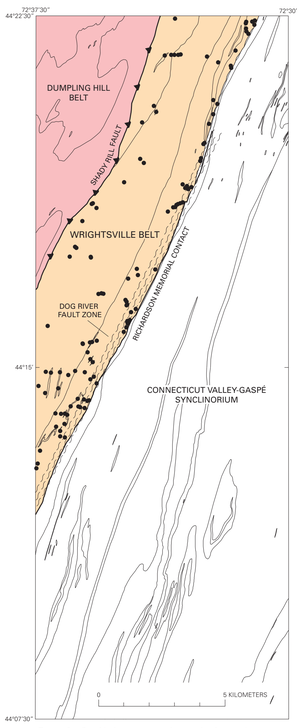
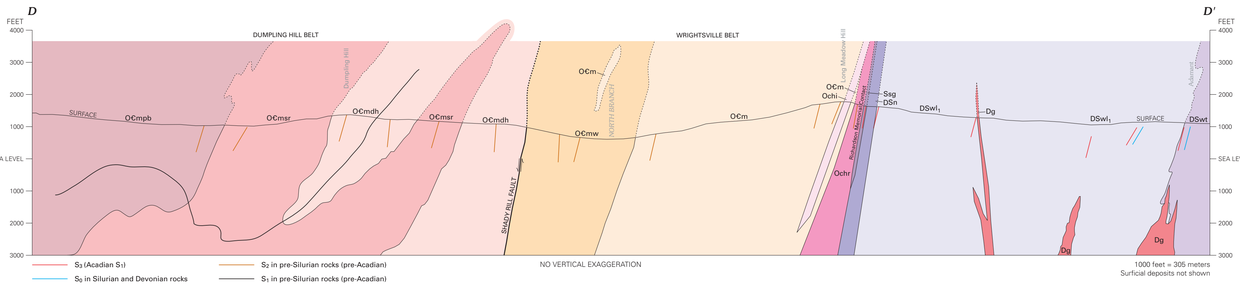
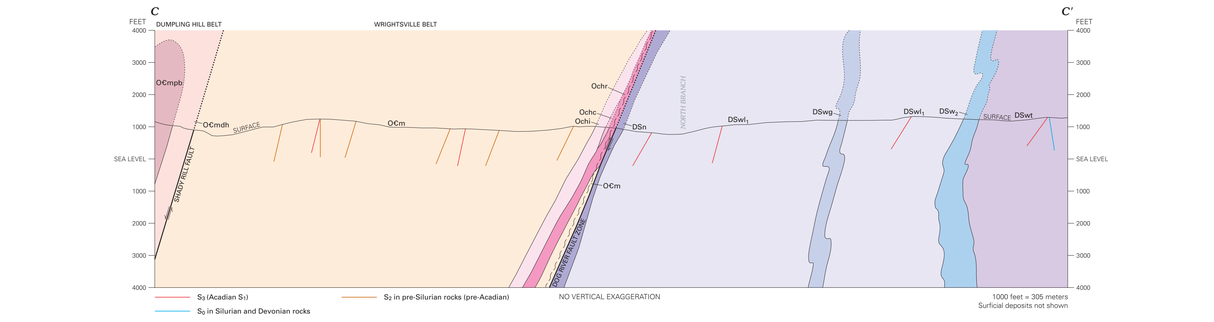


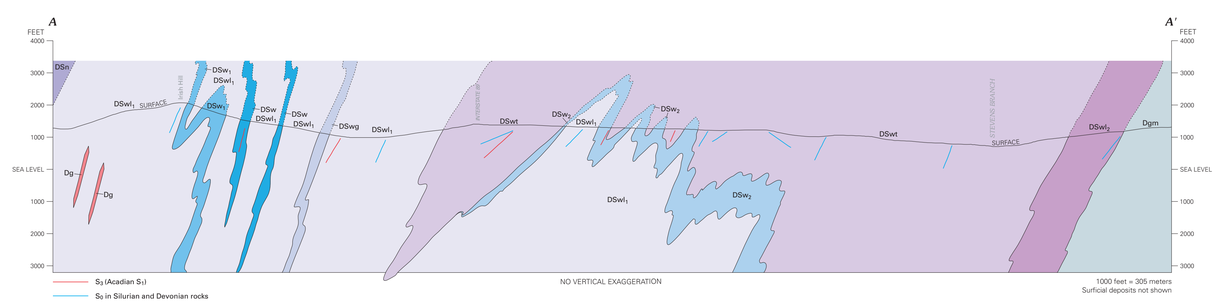
Figure 1.—Simplified tectonic map showing distribution of greenstone and (or) metadiabase mafic rocks (black circles) in the Wrightsville belt.

STOWE	MOUNT WORCESTER	WOODBURY
MIDDLESEX	MONTPELIER	PLAINFIELD
NORTHFIELD	BARRE WEST	BARRE EAST
ROXBURY	BROOKFIELD	WASHINGTON

Index to 7.5-minute topographic maps







Base from U.S. Geological Survey
Montpelier 1999; Barre West 1978 (photorevised 1988)
Transverse Mercator projection. 1927 North American Datum
10,000-foot grid ticks based on Vermont coordinate system
1,000-meter Universal Transverse Mercator grid ticks, zone 18

APPROXIMATE MEAN DECLINATION, 2010

SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 20 FEET

MAP LOCATION

INDEX TO MAPPING
Kim, Gale, King, and Walsh
Walsh

Geology mapped from 2002–05
Digital compilation by Walsh and Kim

BEDROCK GEOLOGIC MAP OF THE MONTPELIER AND BARRE WEST QUADRANGLES, WASHINGTON AND ORANGE COUNTIES, VERMONT

By
Gregory J. Walsh,[1] Jonathan Kim,[2] Marjorie H. Gale,[2] and Sarah M. King[2]
[1]U.S. Geological Survey, Montpelier, VT 05601. [2]Vermont Geological Survey, Waterbury, VT 05671.

2010

USGS science for a changing world

This map is available for sale by U.S. Geological Survey, Information Services, Box 25286, Denver Federal Center, Denver, CO 80225

For product and ordering information:
World Wide Web: http://www.usgs.gov; Telephone: 1-888-ASK-USGS