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# GEOLOGIC MAP OF THE SHERBROOKE–LEWISTON AREA, MAINE, NEW HAMPSHIRE, AND VERMONT, UNITED STATES, AND QUEBEC, CANADA

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## CUSMAP

This map is part of a folio of maps of the Lewiston 1° × 2° quadrangle, Maine, New Hampshire, and Vermont, and part of the Sherbrooke 1° × 2° quadrangle, Maine, New Hampshire, and Vermont, United States, and Quebec, Canada, prepared under the Conterminous United States Mineral Assessment Program (CUSMAP). Adjacent areas in Quebec are shown, in order to illustrate the geologic continuity between northwestern Maine and northern Vermont and New Hampshire. Other results of the project are contained in reports by Nowlan and others (1990a,b,c; stream sediment geochemistry), and Cox (1990; potential tin resources related to the White Mountain Plutonic-Volcanic Suite), Bothner and others (in press; complete Bouguer gravity and aeromagnetic maps), Moench and Boudette (in press, geologic synthesis and mineral occurrence map), and Moench (in press; metallic mineral resources).

## INTRODUCTION

The accompanying map presents the results of geologic bedrock mapping as part of the Sherbrooke-Lewiston project of the Conterminous United States Minerals Assessment Program (CUSMAP). Mapping for this project began in 1978 and was largely completed by the time of the public meeting on the project in September 1984, when a preliminary version of this map was made available (Moench, 1984). The present map contains major revisions of that map, mainly in New Hampshire and Vermont, based on mapping by R.H. Moench and W.A. Bothner in 1985–93; field expsenses for this later work were partly defrayed by the New Hampshire Geological Survey. The purpose of the mapping was to provide the geologic basis for evaluating mineral resources within the United States parts of the Sherbrooke and Lewiston 1° × 2° quadrangles, an area of approximately 25,000 square kilometers. As cited on the map, the work was done by several geologists affiliated with the United States Geological Survey and the Maine Geological Survey. It involved new mapping in several previously unmapped 15-minute quadrangles, and revisions, varying from minor to very extensive, in most previously mapped quadrangles. The earliest systematic geologic mapping in the area (and in New England) was done about 60 years ago by Marland P. Billings in the Littleton and Moosilauke quadrangles (Billings, 1935, 1937). Several major geologic problems that arose during 1978–93 mapping were resolved by means of isotopic dating by J.N. Aleinikoff, one of the authors of this report, and by other cited geochronologists.

This pamphlet contains information that is too lengthy to be printed on the map. Included are brief descriptions of all units shown on the map, endnotes in which questions of stratigraphic nomenclature, age, and correlation are discussed, and references that are cited on the map and in the pamphlet.

## DESCRIPTION OF MAP UNITS

[Stratigraphic definitions, age assignments, and problems are discussed in the numbered notes at the end of this pamphlet. Names of principal tectonic belts and locations of named plutons are shown on figures 3 and 4, which appear on sheet 2. Sites of isotopically determined ages and fossil localities are shown on the principal map. Names of plutons and sites of isotopically determined ages are referenced in the text as "index 80" and "site K–1," respectively.

The geologic time scale of Harland and others (1989) is used in this publication for all geologic periods except the Ordovician Period, for which the four recommended epoch names of Ross and others (1982, sheet 1 of 3) for the United States are used. R. J, Ross, Jr. (written commun. 1992) furnished an updated scale on which he incorporates recently published isotopic age data. On his new scale he divides the Ordovician into the following: Ibex Epoch, lower boundary near 515 Ma, to upper boundary between 485 and 480 Ma; Whiterock Epoch, upper boundary between 461 and 460 Ma; Mohawk Epoch, upper boundary at about 451 Ma; Cincinnati Epoch, upper boundary near 440 Ma, which is near the suggested Ordovician-Silurian boundary of Tucker and others (1990) at about 441 Ma. The epoch (series) term "Early" ("Lower") is used formally only for Cretaceous plutonic rocks and Devonian stratified metamorphic rocks.

The following abbreviations are used in this pamphlet: ME, Maine; NH, New Hampshire; VT, Vermont; PQ, Quebec Province; qd or qds, quadrangle or quadrangles]

## PLUTONIC AND RELATED VOLCANIC ROCKS

[Not necessarily listed in order of age of emplacement. Symbols for plutonic rocks are derived from the triangular diagram shown and explained in figure 1 (see sheet 1). With the exception of plutonic units of suite rank, and some regionally important plutonic rocks of formation rank, formal names that have been used in the past for plutonic rocks are not used]

**White Mountain Plutonic-Volcanic Suite (Early Cretaceous and Jurassic)**—Even though the overall age in New England and Quebec ranges from Triassic to Cretaceous, only Early Jurassic and Early Cretaceous rocks are in the area of this map. Unmetamorphosed alkalic to slightly peraluminous intrusive and associated volcanic rocks of White Mountain batholith (index 81), and many named and unnamed stocks, ring dikes, and cauldrons in NH, VT, and PQ. Magmas of the entire suite in New England and Quebec emplaced or erupted during three separate episodes (Zartman, 1988, p. 1171): at 240–220 Ma (Triassic), 195–155 Ma (Jurassic), and 120–100 Ma (Early Cretaceous)

**Early Cretaceous rocks**—Includes New England–Quebec igneous province of McHone and Butler (1984). Dated at sites K–1 and K–2

K7hx **Porphyritic hornblende-biotite syenite at Pleasant Mountain**—Pleasant Mountain pluton (index 80). Light-gray, coarse-grained, locally porphyritic, hornblende-biotite syenite and subordinate analcite syenite, monzonite, and diorite. Dated at 112±3 Ma (site K–1)

Kvt **Trachyte at Pleasant Mountain**—Pleasant Mountain pluton (index 80). Trachytic tuff exposed at mountain top and pyritized volcanic breccia in Elkins Brook, which drains west side of mountain

K1bx **Porphyritic biotite granite at Megantic Mountain**—Megantic Mountain plutons (index 102). Pink to beige, coarse-grained biotite granite containing phenocrysts of microperthite in matrix of plagioclase, quartz, biotite, and magnetite; matrix fine grained near contacts; contains miarolitic cavities. Dated at 124±2 Ma (site K–2)

K7hb **Hornblende-biotite syenite at Megantic Mountain**—Outer ring dike of Megantic Mountain plutons (index 102). Age determinations consistent with determinations for porphyritic biotite granite and diorite of pluton (124±2 Ma) (site K–2)

K9 **Gabbro-diorite at Megantic Mountain**—Inner ring dike of Megantic Mountain plutons (index 102). Biotite-bearing diorite of pluton dated at 124±2 Ma (site K–2)

**Early Cretaceous or Jurassic rocks**—Undated. May include rocks of New England–Quebec province and (or) rocks of Eastern North America dolerite province of McHone and Butler (1984)

KJvb **Basalt plug at Red Ridge**—Northeast end of Success lobe of Jefferson batholith (index 64), west edge of Old Speck Mountain qd, ME. Plug composed of black, dense alkali-olivine basalt containing olivine phenocrysts; adjacent country rock is brecciated, altered, pyritized, fine-grained Ordovician granite containing abundant limonite

KJ9 **Diorite or gabbro plugs or dike near Bridgton**—Two outcrops south of Bridgton, Norway qd, ME. Massive, medium-grained diorite or gabbro. Although possibly a single pluton, the lack of geophysical expression suggests that outcrops represent small isolated bodies, or possibly a single northeast-trending dike

**Jurassic rocks**—Includes White Mountain Magma Series province of McHone and Butler (1984). Dated at about 201–155 Ma (sites J–1 to J–20)

Jc1b **Conway Granite and Conway-type granite**[1]—Conway Granite of White Mountain batholith (index 81) and similar biotite granite of other bodies (index 83, 79, 42, 55, 43); isotopic ages indicate emplacement in range of 194–155 Ma (sites J–2 to J–4 and J–6 to J–11). Typically pink, medium- to coarse-grained biotite-mesoperthite granite; locally fine grained or porphyritic. Composed of biotite, smokey quartz, mesoperthite, minor oligoclase, and common accessory fluorite; local miarolitic cavities. Locally hydrothermally altered and mineralized with sulfide minerals; has chemical characteristics of types of granite that host mineral deposits in tin-mining districts elsewhere in the world and considered to be source of a major geochemical anomaly for tin and other elements in northern NH (Moench and others, 1984; Cox, 1990)

Jc1bm **Conway-type granite containing abundant plutonic inclusions**—In Cannon Mountain lobe of White Mountain batholith (index 83) contains angular inclusions of Devonian Kinsman Granodiorite (Dk2bx). In Pilot-Pliny plutons (index 55) contains inclusions of rocks of Ordovician and Silurian(?) Oliverian Plutonic Suite; matrix of pink, fine-grained biotite granite appears to be Conway-type granite

J1f **Intrusive rhyolite of Gay Brook ring dike(?)**—Possible ring dike (index 43A) south of Gore Mountain plutons (index 43), Guildhall qd, NH; best exposed at approximate elevation 1,200 ft in Gay Brook, which drains southeast side of Goback Mountain. Also exposed in Connary Brook, Guildhall qd, and at two other localities. Light-pink, aphanitic rhyolite containing small orthoclase phenocrysts and locally conspicuous accessory fluorite

Jo1h **Mount Osceola Granite**—Hornblende-biotite-mesoperthite granite of White Mountain batholith (index 81). Typically green, medium to coarse grained; composed of mesoperthite, quartz, ferrohastingsite, and small amounts of biotite, ferrohedenbergite, and fayalite. Locally interlayered with, and not easily distinguished from, Conway Granite or Conway-type granite (Jc1b). Possibly includes small body of pink hornblende-biotite granite at east side of Pilot-Pliny plutons (index 55). Dated at 186.8±1.2 Ma at site J–16

J1–4lv **Leucocratic granite to quartz syenite**—Small body near Gore Mountain plutons (index 43) and Owlhead Mountain pluton (index 41). Light-pink to tan, variably porphyritic perthite granite to quartz syenite; contains sparse plagioclase and traces of biotite and opaque minerals

J1hx **Hornblende granite porphyry**—Granite porphyry of Crescent Range ring dike (index 56), feldspar-porphyritic granite of Pilot-Pliny plutons (index 55), porphyritic granite at Robbins Ridge, at east side of White Mountain batholith (index 81) and Mount Lafayette Granite Porphyry at northwest side of White Mountain batholith (index 81). In Crescent Range ring dike, rock is pink to gray, medium-grained; contains large phenocrysts of quartz and microperthite, small phenocrysts of hastingsite and biotite, and groundmass of same minerals and magnetite. In Pilot-Pliny plutons, dated at 188±5 Ma and 183.2±1.8 Ma (sites J–5, J–10); typical rock is pink to gray granite containing phenocrysts of quartz and (or) microperthite; may contain biotite, fayalite, hedenbergite, and hastingsite. At Robbins Ridge, rock is white granite with phenocrysts of microperthite in a matrix of oligoclase, microperthite, quartz, amphibole, and biotite. Mount Lafayette Granite Porphyry composed of granite to syenite; contains phenocrysts of perthite, quartz, fayalite, ferrohedenbergite, and ilmenite, set in matrix of quartz, orthoclase, and ferrohastingsite; dated at about 195 Ma (site J–19)

J1r **Riebeckite granite**—Northeastern lobe of White Mountain batholith (index 81), Pilot-Pliny plutons (index 55), Hart Ledge plutons (index 82), and ring dike 20 km to east of Hart Ledge. Typically bluish green or white, medium to coarse grained; contains mesoperthite or microperthite, quartz, and interstitial riebeckite and, locally, hornblende. Body in White Mountain batholith dated at 177±5 Ma (site J–15)

J4h **Hastingsite or ferrorichterite quartz syenite**—Monadnock Mountain, Gore Mountain, and Pilot-Pliny plutons (index 44, 43, 55), and plutons near east side of White Mountain batholith (index 81). Granite segregations in Monadnock Mountain plutons dated at 171±4 Ma (site J–1); body in Pilot-Pliny plutons dated at 183.2±1.8 Ma (site J–10). Typically greenish-gray to pink, medium-grained, equigranular to subporphyritic mesoperthite quartz syenite; may contain minor plagioclase or hedenbergite

J4hx **Porphyritic hornblende quartz syenite**—Mount Garfield and Albany Porphyritic Quartz Syenites of White Mountain batholith (index 81). Mount Garfield dated at 201±6 and 193±6 Ma (site J–13); contains abundant phenocrysts of microperthite and fewer phenocrysts of quartz, fayalite, ferrohedenbergite, ferrohastingsite (as rims around ferrohedenbergite and ferrohastingsite), and ilmenite; matrix fine grained, composed of quartz, orthoclase, and ferrohastingsite. Albany dated at 170±3 Ma (site J–14, southern ring dike) and 179±5 Ma (J–17, northern ring dike); contains abundant phenocrysts of smokey quartz and white perthite, and sparse phenocrysts of ferrohedenbergite, fayalite, and ilmenite, set in fine-grained matrix of perthite, quartz, oligoclase, and ferrohastingsite

J5h **Hornblende-biotite quartz monzodiorite, quartz monzonite, and diorite**—Pilot-Pliny plutons (index 55); dated at 183.2±1.8 Ma (site J–10). Includes dark-gray, medium- to coarse-grained quartz monzodiorite in ring dike, and quartz monzodiorite, diorite, and quartz monzonite in central stock of southern part of plutons; typically contains less than 10 percent quartz, and 10–25 percent total hornblende, biotite, chlorite, pyroxene, and opaque minerals

J6h **Hornblende-biotite quartz diorite**—Small body at west edge of Cannon Mountain lobe of White Mountain batholith (index 83). Gray, coarse grained; contains andesine, biotite, hornblende, and quartz

J7h **Hornblende or ferrorichterite syenite and quartz syenite**—Gore Mountain, Pilot-Pliny, Cherry Mountain, and Hart Ledge plutons (index 43, 55, 62, 82). Gore Mountain, Pilot-Pliny, and Cherry Mountain: typically bluish green, variably coarse and medium grained; contains microperthite and minor quartz, hedenbergite, hornblende, and fayalite. Hart Ledge: dark green, medium to coarse grained; composed of microperthite, sodic ferrohedenbergite, ferrorichterite, and 0–20 percent quartz; dated at 168±1 Ma and 163±5 Ma (site J–12)

J7hx **Porphyritic hornblende syenite**—Body at Mount Carrigain in White • Mountain batholith (index 81), and in Cape Horn ring dike (index 54). Cape Horn: dark green to black; contains tabular phenocrysts of orthoclase in fine-grained to aphanitic matrix of potassium feldspar. In Mount Carrigain: gray; contains sparse phenocrysts of microperthite set in matrix of microperthite, ferrohastingsite, and sparse quartz; dated at 193±2 Ma (site J–18)

J9Ah **Hornblende-biotite diorite**—Monadnock Mountain and Gore Mountain plutons (index 44, 43). Monadnock Mountain: dark gray, medium grained; contains andesine, hornblende, biotite, and pyroxene. Gore Mountain: gray, coarse-grained diorite composed of oligoclase, biotite, hornblende, and hastingsite, and minor quartz, perthite, and pyroxene

J9B **Olivine-augite gabbro**—Small body exposed in Dry River, Crawford Notch qd, New Hampshire. Dark green, medium grained, ophitic; contains labradorite, olivine, augite, and minor biotite and hornblende

Jmv **Moat Volcanics**—Bodies in White Mountain batholith (index 81). Mainly rhyolite tuff, tuff-breccia, and trachyte; local basalt, and andesite. Tuff-breccia contains blocks of comagmatic volcanic and intrusive rocks, and Paleozoic country rocks. On south side of body at Kearsarge North mountain is a downdropped slice of greenschist-facies slate derived from Lower Devonian Littleton Formation (Dl). Rhyolite tuff dated at 173.1±1.5 Ma (lower part of Moat) and 168.2±1.5 Ma (upper part of Moat), and trachyte dated at 169±4 Ma and 162±4 Ma (all determinations at site J–20)

**Sebago batholith and related bodies (Pennsylvanian)**—Metamorphosed, strongly peraluminous two-mica granite emplaced as a thin subhorizontal sheet. Muscovite probably originally primary, but extensively recrystallized during metamorphism. Batholith (index 78) dated at 290–300 Ma (sites C–1, C–2)

ℙ1mv **Variably textured two-mica granite**—Main body of Sebago batholith (sites C–1, C–2). Light gray to pink, fine to coarse grained, equigranular to subporphyritic, commonly pegmatitic; composed of quartz, perthitic microcline, sodic oligoclase, biotite, muscovite, and scattered garnet; muscovite commonly occurs as large poikiloblasts of probable metamorphic origin

ℙ1mm **Two-mica granite containing abundant metasedimentary inclusions**—Eastern margin of Sebago batholith. Similar to main body, but lacks pink coloration and contains abundant lenticular inclusions of stratified metamorphic rocks. Inclusions aligned subparallel to northeastern contact of batholith and to structural grain of country rocks. Correlation of isolated bodies east of batholith with main body of Sebago is uncertain

**Androscoggin Lake plutons (Mississippian?)**—Composed of alkalic, mafic to ultramafic rocks and alkalic felsic rocks; mafic to ultramafic rocks cut by swarms of alkalic diabase dikes, which are confined to the plutons (index 74) (Creasy, 1983). Tentative age of about 330 Ma determined at site C–4

M4h **Hornblende-pyroxene quartz syenite**—Grades locally to granite or syenite. Massive, medium grained; contains microperthite and small amounts of ferrohastingsite and clinopyroxene

M7h **Hornblende-biotite syenite**—Medium grained; composed of orthoclase, microperthite, and as much as 15 percent hornblende and biotite. Cataclastic fabric exposed within eastern part of largest body

M9hu **Hornblende diorite to gabbro and pyroxenite**—Diorite to gabbro variably leucocratic to melanocratic, coarse grained; contains sodic to calcic plagioclase, hornblende, and pyroxene. Pyroxenite composed mainly of clinopyroxene and subordinate hornblende; intruded by diorite to gabbro of pluton. Gabbro dated at about 330 Ma (site C–4)

M1m **Two-mica granite of Long Mountain pluton (Mississippian)**—Granite of pluton (index 40) is light gray, medium grained, typically equigranular; locally subporphyritic; commonly foliated near contacts. Contains quartz, oligoclase, microcline (slightly less abundant than oligoclase), 8–10 percent of muscovite plus biotite, and accessory epidote, opaque minerals, apatite, and zircon. Long Mountain pluton dated at about 350 Ma (site C–3)

Du **Remobilized ultramafic rocks (Devonian?)**—Small bodies of serpentinite along Acadian faults in Chain Lakes and Kennebago Lake qds, ME, and small bodies of serpentinite and metaperidotite in Arnold Pond and Moose Bog qds, ME, where three bodies occur along or near Diamond Pond fault (DiPF). Metaperidotite is dark green, massive to schistose; contains euhedral magnetite crystals, anhedral oikocrysts of brown hornblende as large as 3 cm across containing inclusions of relict augite, and blocky pseudomorphs of actinolite possibly after hypersthene or olivine; where sheared, partly altered to chlorite and fibrous amphibole. The serpentinite is white to tan weathering, dark green, massive to schistose; characterized by anastomosing shears commonly lined with slip-fiber asbestos and locally cut by veinlets of cross-fiber asbestos; contains clinochrysotile, magnesium chlorite, talc, carbonate, and magnetite. Interpreted as variably hydrated, remobilized ultramafic rocks diapirically emplaced along faults by Acadian compression. Assigned age is inferred time of diapiric emplacement. Whereas bodies exposed southeast of ultramafic bodies of Boil Mountain Complex (Ꞓb9u) outcrops were probably derived from the complex, those exposed along the Second Lake rift axis (fig. 3, SLRA) might have been derived from mantle below the rift

**New Hampshire Plutonic Suite (Devonian)**—Unmetamorphosed or weakly metamorphosed, massive to weakly foliated felsic and intermediate rocks in discordant, predominantly mesozonal plutons throughout map area, and strongly metamorphosed, moderately to strongly foliated felsic rocks in semiconcordant plutons near southwest corner of area. Divided into five petrographic assemblages that are not necessarily comagmatic, on the basis of composition and characteristic mineralogy. Ages range from about 410 Ma to 365 Ma (sites D–1 to D–9, D–11 to D–13, D–15, and D–16)

**Assemblage I**—Probable youngest Devonian granitic intrusive rock; peraluminous biotite granite

D1bv **Variably textured biotite granite**—French Pond, Newark and Alderbrook plutons (index 91, 49, 60). Unfoliated, unmetamorphosed, pink, medium to coarse grained, locally porphyritic; composed of quartz, albite, potassium feldspar, biotite, and sparse to abundant muscovite. Newark pluton is the locus of a major aeromagnetic anomaly; contains abundant perthite, green biotite, and abundant accessory magnetite. Granite of French Pond pluton dated at 365±3 Ma (site D–8)

**Assemblage II**—Two-mica granite and related rocks. Typically unmetamorphosed, strongly peraluminous; common accessory garnet and tourmaline. May be affected by Pennsylvanian metamorphism near Sebago batholith (index 78). Available isotopic dates suggest emplacement between about 400 Ma (site D–3) and 371 Ma (site D–4)

D1mp **Pegmatitic granite and pegmatite**—Whitecap Mountain pluton (index 30) and part of Rumford plutons (index 29); largest of many small bodies in southwestern ME, including many pegmatites quarried in the past for feldspar, mica, beryllium, and lithium; some host famous rare-mineral localities. Typically resistant and cap hills; white, composed principally of quartz, perthite, sodic plagioclase, mica, and accessory garnet; some zoned (Cameron and others, 1949)

D1m **Two-mica granite**—Several named and unnamed bodies in map area (index 21, 31, 34A, 37, 40, 47, 65–67, 70–73, 75, 76). Dated at 399±3 Ma (site D–3), 376±9 Ma (site D–12), and 371±6 Ma (site D–4). Mainly light gray, massive, fine to medium grained, equigranular; composed of quartz, microcline, sodic plagioclase, muscovite, biotite, and accessory garnet, tourmaline, apatite, and zircon. Muscovite mainly primary, but may be recrystallized in some bodies. Willoughby pluton (index 47) dated at 376±9 Ma (site D–12), atypical; leucocratic, seriate, locally pegmatitic; contains miarolitic cavities

D1mm **Two-mica granite containing abundant granodiorite to quartz diorite inclusions**—Part of Mooselookmeguntic batholith (index 34A); granodiorite to quartz diorite of unit D2–6 occurs as randomly oriented angular inclusions in massive two-mica granite of unit Dlm

**Assemblage III**—Biotite or hornblende-biotite granite to quartz diorite; muscovite absent. Typically unmetamorphosed, probably metaluminous rocks of intermediate composition; common accessory minerals are primary epidote, allanite, and sphene. Bodies near Sebago batholith (index 78) may be strongly affected by Pennsylvanian metamorphism. Rocks grade locally to diorite or gabbro of assemblage V, particularly near margins of plutons. Available isotopic age data suggest emplacement at about 373 to 367 Ma (sites D–2A, D–2B, D–2C, D–15), and 391–382 Ma (sites D–5, D–7, D–11, D–13). Characteristic minerals omitted from symbols to help distinguish from assemblage IV

D3A **Biotite and hornblende-biotite tonalite**—Remick pluton (index 59). Gray, fine- to medium-grained tonalite composed of quartz, oligoclase, biotite, and local hornblende; contains swarms of small euhedral epidote crystals

D2–3A **Biotite granodiorite and hornblende-biotite granodiorite to tonalite**— Hog Island, Seven Ponds, and part of Chain of Ponds plutons (index 5, 9, 8). Hog Island dated at 367±7 Ma (site D–15), Chain of Ponds dated at 373.3±2 Ma (site D–2A), and Seven Ponds dated at 367.6±1.3 Ma (site D–2B). Light-gray, medium- to coarse-grained, equigranular to subporphyritic granodiorite and local granite containing biotite and local subordinate hornblende; grades to finer grained, darker gray tonalite containing as much as 6 percent hornblende

D5 **Biotite and hornblende-biotite quartz monzodiorite**—Nulhegan, Victory (east lobe), Parmachenee plutons (index 48, 52, 13), and southern part of Phillips batholith (index 26B). Nulhegan pluton dated at 390±14 Ma (site D–13); Parmachenee pluton dated at about 391 Ma (site D–11). Gray, massive to foliated, medium- to coarse-grained quartz monzodiorite and local granite, quartz monzonite and granodiorite; composition of Lees Hill pluton uncertain

D5–6 **Hornblende-biotite quartz monzodiorite to quartz diorite**—Umbagog pluton (index 36); dated at 384±6 Ma (site D–5). Dark gray, massive to weakly foliated, medium to coarse grained; commonly contains one or two pyroxenes; locally grades to gabbro at border of pluton

D5x **Feldspar-megacrystic hornblende-biotite quartz monzodiorite**—Small body near southeast end of Umbagog pluton (index 36), Old Speck Mountain qd, ME. Dark gray, strongly foliated, medium grained; contains large euhedral microcline porphyroblasts that locally have grown across contacts of metasedimentary inclusions

D2–6 **Biotite and hornblende-biotite granodiorite to tonalite or quartz diorite**—Spider Lake (Lac aux Araignees), Chain of Ponds and Songo plutons, and parts of Rumford pluton and Mooselookmeguntic batholith (index 7, 8, 69, 29, 34B). Spider Lake dated at 367.7±1.3 Ma (site D–2C); Chain of Ponds dated at 373.3±2 Ma (site D–2A); Songo dated at about 382 Ma (site D–7). Gray, unfoliated to strongly foliated, equigranular, fine to coarse grained; foliation primary, parallel to contacts. At southeast end of Mooselookmeguntic batholith, grades to hornblende quartz monzodiorite to gabbro (unit D5–9B; index 34C). Rocks of Songo pluton and southern edge of Mooselookmeguntic batholith are affected by Pennsylvanian metamorphism that followed emplacement of Sebago batholith (index 78). Metamorphism of Songo described by Gibson and Lux (1989)

D6 **Hornblende-biotite quartz diorite**—Small bodies between Gorham and Songo plutons (index 66, 69), at border of Lexington batholith (index 21), and 4 km southeast of Rumford plutons (index 29). Dark gray, massive and medium grained to schistose and fine grained. Smallest bodies are finest grained, deformed, and have schistosity that crosses intrusive contacts

**Assemblage IV**—Muscovite-bearing biotite granodiorite to granite and tonalite. Unmetamorphosed to strongly metamorphosed peraluminous rocks, most of which vary from granodiorite to granite or tonalite; also includes one body of trondhjemite and one of quartz syenite. Kinsman Granodiorite (Dk2bx) and Bethlehem Granodiorite (Db2b) (names revised herein) are strongly foliated and metamorphosed, owing to synorogenic emplacement at mid-crustal level; other bodies near Sebago batholith (index 78) may be affected by Mississippian metamorphism. Rocks locally grade to diorite or gabbro of assemblage V. Available isotopic age data suggest emplacement in Early Devonian, possibly as early as about 414 Ma (site D–6), mainly between about 410 and 393 Ma (sites D–3, D–9, D–16), and possibly as late as about 376 Ma (site D–12)

D1b **Biotite granite**—North lobe of Lexington batholith (index 21), Magalloway Mountain pluton (index 14), and possibly the Hereford Mountain pluton (index 101), Morse Mountain sheet (index 53A), and small bodies in Dixville qd. Lexington batholith dated at 399±3 Ma (site D–3). Rock of Lexington batholith, Magalloway Mountain, and Hereford Mountain plutons is mainly light-gray, coarse-grained, equigranular, two-feldspar biotite granite containing minor muscovite. Rock of Morse Mountain sheet composed of weakly to strongly foliated, pinkish-gray, medium-grained, equigranular granite containing clots of biotite, chlorite, and sparse muscovite; intruded by many metadiabase dikes. Rocks of bodies in Dixville qd typically strongly foliated; composed of gray, fine-grained, equigranular biotite granite, locally abundant sheared pegmatite, and local probable granodiorite and tonalite; bodies vary from irregular dikelets a few centimeters thick to lobate lenses several meters thick and were probably emplaced into heated, visco-plastic country rocks

D1bm **Biotite granite containing abundant metasedimentary inclusions**—Maidstone pluton (index 50); inclusions of metamorphic rocks abundant throughout. Where least contaminated, composed of white to pink, medium- to coarse-grained, massive to porphyritic, muscovite-bearing biotite granite

D1–4bx **Porphyritic biotite granite and quartz syenite**—Center segment of Lexington batholith (index 21); dated at 399±3 Ma (site D–3). Gray, variably to strongly porphyritic; contains tabular phenocrysts of alkali feldspar, 2–13 cm in length, in a fine- to medium-grained matrix of quartz, oligoclase, biotite, and muscovite. As phenocryst content increases, rock composition changes from granite to quartz syenite

D1–2b **Biotite granite and granodiorite**—Northern parts of Phillips batholith and Echo Pond plutons (index 26A, 46A), and Willoughby and Averill plutons (index 47, 45). Phillips batholith dated at 404±10 Ma (site D–16); composed of gray, medium-grained, equigranular, muscovite-bearing biotite granite and granodiorite, which commonly grades to tonalite near contacts and is intruded by abundant two-mica granite similar to unit D1m. Predominant rock of Averill and Echo Pond plutons composed of pink to gray, muscovite-bearing biotite granite and granodiorite. In Echo Pond plutons, granite and granodiorite grade through hornblende quartz monzodiorite to gabbro of unit D5–9B

D1bx **Porphyritic biotite granite**—Flagstaff Lake plutons (index 19B) and southwest corner of Mooselookmeguntic batholith (index 34A). Gray, medium to coarse grained; contains blocky phenocrysts of perthite and sparse oligoclase, typically 1.5–3 cm long; primary foliation expressed by alignment of phenocrysts parallel to contacts. Flagstaff Lake pluton dated at 414±12 Ma (site D–6); although data suggest a Late Silurian age, pluton intrudes and has metamorphosed strata of Lower Devonian Seboomook Group (unit Dsu)

D2b **Biotite granodiorite**—Cupsuptic, Lincoln Pond, Bunker Pond, and Sabattus plutons (index 16, 15, 28, 77), small parts of Redington pluton (index 25), and probably the Victory (west lobe) pluton (index 51). Gray, medium-grained, equigranular to subporphyritic granodiorite; grades locally to granite. In Redington pluton, grades to porphyritic granodiorite

D2bx **Porphyritic biotite granodiorite**—Redington pluton (index 25). Gray, medium to coarse grained; contains abundant phenocrysts of perthitic microcline, typically 1.5–3 cm long, aligned subparallel to contacts. Granodiorite may grade to granite where phenocrysts are most abundant

D3B **Trondhjemite**—Howard Pond pluton (index 32), about 2.5 km north of northern tip of Songo pluton (index 69). Light gray, weakly foliated, medium grained; contains minor biotite, muscovite, and accessory garnet

Dk2bx **Kinsman Granodiorite**—Lincoln and North Baldface plutons (index 84, 68) and nearby bodies. Previously mapped as Kinsman Quartz Monzonite (Billings, 1956); name changed herein to Kinsman Granodiorite because average composition is granodiorite according to the Streckeisen (1973) classification. Strongly metamorphosed, foliated, gray, medium- to coarse-grained granodiorite that locally grades to granite or tonalite; characterized by abundant deformed megacrysts of microcline as much as 7 cm long, set in a matrix of medium-grained granodiorite; locally contains garnet

Db2b **Bethlehem Granodiorite**—Haverhill and Mount Clough plutons (index 90, 85), and Indian Pond and Fairlee plutons (index 95, 94) south of map area. Previously mapped as Bethlehem Gneiss (Billings,1956); name changed herein to emphasize average granodiorite compositition. Strongly metamorphosed, foliated, gray, medium-grained, mainly biotite granodiorite; contains sparse to abundant secondary muscovite; locally contains elliptical feldspar megacrysts similar to those of the Kinsman Granodiorite (Dk2bx). Granodiorite grades locally to tonalite or granite; Indian Pond pluton composed of granite and granodiorite; Fairlee pluton composed of granite and is chilled and slightly porphyritic at northern contact. U-Pb zircon data obtained from Mount Clough pluton (site D–9) consistent with age of 410±5 Ma obtained from Fairlee pluton and 407±5 Ma from Indian Pond pluton (Kohn and others, 1992)

**Assemblage V**—Mafic and hybrid rocks. Variably weakly to strongly metamorphosed. Includes massive and layered gabbro and locally associated ultramafic rocks (D9B) of many plutons in ME; quartz monzodiorite to gabbro (D5–9B) gradational to more felsic parts of Mooselookmeguntic batholith (index 34C), ME, and Echo Pond pluton (index 46B), VT; diorite (D9A) of Huston Brook (index 19A) and other plutons in ME; diabase (DS9) of sheeted dikes in Waterford (index 93); and garnetiferous pentlandite-bearing tonalite (D3Ag) of West Mountain plutons (index 27), ME

D9B **Gabbro, troctolite, norite, epidiorite, and minor ultramafic rocks**—Flagstaff Lake, Elephants Head, Pierce Pond, Bog Brook, Sugarloaf, and Plumbago plutons (index 19, 18, 20, 22, 24, 33), and many small bodies. Unmetamorphosed to weakly metamorphosed northeast of Rangeley Lake, ME; variably metamorphosed to greenschist and amphibolite facies southwest of Rangeley Lake. Foliated granitic rock in Sugarloaf pluton (index 24), presumed to be comagmatic with gabbro of pluton, tentatively dated at 406±12 Ma (site D–1). Variably black to dark greenish gray, massive to conspicuously layered, fine to coarse grained. Where weakly recrystallized northeast of Rangeley Lake, common types are olivine gabbro, two-pyroxene gabbro, biotite-hornblende gabbro, and anorthosite; cumulate textures locally preserved; primary layering typically at large angle to contacts. Elephants Head pluton (index 18) contains minor biotite granodiorite. Plumbago pluton (index 33) is a funnel-shaped body of metamorphosed, poorly layered gabbro containing minor ultramafic rocks and fine-grained tonalite. Some bodies closely related to Early Devonian and Silurian listric normal faults: Sugarloaf pluton emplaced along Barnjum fault (BF); Plumbago pluton and unnamed amphibolite dike emplaced along Plumbago Mountain fault (PMF); several small unnamed intrusive amphibolite bodies in Old Speck Mountain qd emplaced along Mahoosuc fault (MF), and on the hanging-wall side near the fault

D5–9B **Hornblende quartz monzodiorite to gabbro**—South lobe of Echo Pond plutons (index 46) and southeast end of Mooselookmeguntic batholith (index 34C). Echo Pond: quartz monzodiorite is faintly layered; composed of andesine, potassium feldspar, and hornblende; grades to granite and granodiorite of north lobe of pluton (D1–2b) and to gabbro of south lobe. Mooselookmeguntic: similar to rock of Echo Pond, but less well studied

D9A **Diorite**—Biotite-hornblende-pyroxene diorite in Flagstaff Lake plutons (index 19), diabase of Bean Brook Mountain sill (index 1), and diorite of Huston Brook pluton (index 23). In Huston Brook pluton, composed of dark-gray, medium-grained diorite containing sparse phenocrysts of plagioclase, mixed with light-gray, medium-grained, feldspar-porphyritic granite

D9 **Epidiorite**—Small plugs in Littleton and Moosilauke qds previously mapped as Moulton Diorite (Billings, 1935); name not used in this publication. Retrograded gabbro or diorite composed of albite, actinolite or hornblende, epidote and chlorite, and minor amounts of opaque and carbonate minerals, quartz, biotite, and sericite

D3Ag **Garnetiferous pentlandite-bearing tonalite**—West Mountain plutons (index 27), northeastern Rumford qd, ME. Rusty-weathering, medium-grained tonalite containing 10–15 percent magnesium-rich biotite, several percent almandine garnet, sparse secondary anthophyllite, and scattered 1-cm nodules of graphically intergrown pyrrhotite and pentlandite; intrudes nearby biotite granodiorite (D2b) and intruded by unmapped two-mica granite (D1m). Tentatively interpreted as hybrid of felsic and ultramafic magmas

**Intrusive rocks of Second Lake rift (Early Devonian and Silurian)**—Includes plutons and dikes that intrude Silurian western rift and Piermont sequences (Second Lake rift sequences) in Piermont-Frontenac allochthon and sheeted dike bodies that locally intrude Lower Devonian Meetinghouse Slate Member, tentatively considered to have been deposited over the allochthon while in transit. The Silurian intrusive rocks are considered to be comagmatic with volcanic rocks of the rift sequences. Variably foliated and metamorphosed at ambient grade of country rocks. Includes sheeted dikes in Waterford (index 93) and at Leighton Hill and Peaked Mountain (index 99, 100), probably most of the mafic and felsic dikes of swarms shown on map, high-level granite of East Inlet pluton (index 12), and other bodies. Rocks of basaltic composition have chemical characteristics of basalts erupted in regions undergoing tectonic extension (Chevé and others, 1983; Eisenberg,1983; Ebinger, 1985; Hafner-Douglass, 1986; Chevé, 1991; R.H. Moench, unpub. data, 1984). Interpreted as a bimodal magmatic expression of Silurian tectonic extension that prevailed at site of origin of Second Lake rift

DS9 **Sheeted and massive diabase and gabbro dikes (Early Devonian and Silurian)**—Bodies of sheeted dikes in Waterford (index 93), at Leighton Hill (index 99), and at Peaked Mountain (index 100); composed of weakly to strongly metamorphosed and foliated, variably fine- to medium-grained diabase and massive to foliated, coarse-grained, locally pegmatitic gabbro; irregular dikelets and sheets of granite (some two-mica granite) or aplite locally form as much as 50 percent of an outcrop. Metadiabase composed of albite or oligoclase, hornblende, epidote, and minor amounts of opaque and carbonate minerals, chlorite, biotite, and sericite; commonly has abundant blocky plagioclase phenocrysts as much as 1 cm across. Also includes extensive massive to foliated greenstone dikes and sills in Frontenac Formation (Sfr), pluglike bodies of greenstone or low-rank amphibolite in Smalls Falls Formation (Ssf) at Magalloway Mountain, and probably many unmapped greenstone or amphibolite dikes and sills of the swarms, shown on map

DS1f9 **Sheeted bimodal dikes (Early Devonian? and Silurian)**—Marble Mountain sheeted dikes (index 11), at ME-PQ border. Weakly metamorphosed sheeted felsite, felsite porphyry, diabase, and gabbro. Description from Chevé (1978) and observations by E.L. Boudette. Undated, but considered a feeder to Silurian mafic and felsic metavolcanic rocks of Second Lake rift axis; Early Devonian age not ruled out

S1b **Hypabyssal biotite granite (Silurian)**—East Inlet pluton (index 12). Weakly metamorphosed and foliated, light-gray, fine-grained two-feldspar granite containing about 5 percent biotite or chlorite, and accessory zircon, allanite, apatite, and sphene; alteration products are chlorite, sericite, epidote, and stilpnomelane. Common granophyric texture indicates near-surface emplacement. Intrudes largest basalt lens of Silurian Frontenac Formation (Sfrb); pillowlike as well as angular contacts exposed. Dated at 430±4 Ma (site S–1)

S1bm **Mixed biotite granite and intermediate to mafic rocks**—Western border facies. Variably medium- to dark-gray and greenish-gray, fine- to medium-grained rocks of probable dioritic composition mixed with variable amounts of biotite granite; mafic rocks show pillowlike and angular contacts and local evidence of chilled contacts against biotite granite

**Oliverian Plutonic Suite[2] (Silurian? and Ordovician)**—Semiconcordant, epizonal to mesozonal intrusive core rocks of Oliverian domes of Bronson Hill anticlinorium (fig. 3). Massive to gneissic; range in composition from granite to trondhjemite and syenite. Isotopic age data indicate emplacement in the range of about 441–458 Ma (sites O–1, O–2, O–8, O–10, O–12), and possibly as late as 435 Ma (site S–3). Probably coeval with felsic volcanic rocks of Quimby Formation (Oqv) and in part coeval with Ammonoosuc Volcanics (Oa)

**Silurian (Llandoverian) or Ordovician (late Cincinnatian) rocks**

SOo1bl **Leucocratic biotite granite**—Moody Ledge pluton (index 88) and remnant of Moody Ledge to east (index 89). Isotopic age of 435±3 Ma (site S–3) obtained from high-temperature mylonitic zone in eastern remnant probably indicates age of mylonitization. Age of 450±2 Ma obtained from main body (site O–14) determined too late to modify age assignment. Both bodies grade from massive and homogeneous biotite granite to strongly foliated and banded mylonitic granite gneiss. Foliated zones indicated by pattern on map. Where massive, rock is pink to light gray, fine grained; composed of quartz, microcline, sodic oligoclase, sparse biotite, and accessory muscovite, magnetite, sphene, zircon, apatite, and ilmenite. Banding in foliated zone locally resembles bedding, but displays anastomosing shears, magnetite stringers, and aplitic segregations along the shears

SOo4–7h **Hornblende-biotite syenite to quartz syenite**—Part of Jefferson batholith (index 63). Dated at 441±5 Ma (site O–1), which is approximately on the Ordovician-Silurian time boundary (Tucker and others, 1990). Pink, foliated, medium grained to coarsely porphyritic; composed of microcline crystals in a generally subordinate groundmass of oligoclase, quartz, hornblende, and biotite

SOo1h **Hornblende-biotite granite**—Part of Jefferson batholith (index 63). Pink, weakly foliated, coarse grained; composed of quartz, microcline, oligoclase, minor biotite and hornblende, and accessory magnetite. Considered approximately coeval with dated hornblende-biotite syenite to quartz syenite (SOo4–7h)

SOo4Ch **Hornblende-biotite quartz monzonite**—Part of Jefferson batholith (index 63). Pink, foliated, fine to coarse grained, locally porphyritic; contains nearly equal amounts of microcline and oligoclase or andesine, and subordinate quartz, hornblende, and biotite. Considered approximately coeval with dated hornblende-biotite syenite to quartz syenite (SOo4–7h)

SOo4bx **Porphyritic biotite quartz syenite**—Part of Jefferson batholith (index 63), at Bray Hill, Whitefield qd. Mapped by R.H. Arndt (unpub. mapping, 1949) and described by G.W. Leo (written commun., 1988) as foliated porphyritic biotite quartz syenite. Considered approximately coeval with dated hornblende-biotite syenite to quartz syenite (SOo4–7h)

**Ordovician rocks (Cincinnatian and Mohawkian)**

Oo1b **Biotite granite**—Owls Head and Sugar Hill plutons (index 92, 86), and parts of Jefferson batholith (index 63) and Success lobe (index 64) of Jefferson batholith; dated at 444±8 Ma (site O–2, pooled data) and 456±3 Ma (site O–8). Southwest of map area, includes Baker Pond, Smarts Mountain, and Mascoma plutons (index 96, 98, 97). Typically pink to light gray, weakly to strongly foliated, medium grained, equigranular to subporphyritic; composed of quartz, microcline, oligoclase, biotite, minor muscovite, and accessory magnetite, sphene, pyrite, zircon, and apatite. Southwest end of Jefferson batholith contains the Scrag Granite as used by Billings (1937, p. 510), dated at 456±3 Ma (site O–8); weakly foliated, pink, medium- to coarse-grained biotite granite; modal and chemical data (Billings, 1937, table 19; Moench and others, 1984, table 1) indicate an unusually potassium-rich composition; intrudes strongly foliated probable granodiorite (Oh2b?) of Whitefield pluton (index 61), which intrudes Ammonoosuc Volcanics (Oa)

Oo1bx **Porphyritic biotite granite**—Parts of Jefferson batholith (index 63). Pink, foliated, two-feldspar biotite granite containing phenocrysts of microcline, typically about 1.5 cm long, in a fine- to medium-grained groundmass; typically contains minor muscovite; grades to equigranular biotite granite. Considered approximately coeval with other Ordovician granites of suite that have been dated

Oo2hl **Leucocratic hastingsite granodiorite**—Landaff pluton (index 87). Predominantly leucocratic granodiorite, but ranges from granite to trondhjemite. Pink to light gray, massive to weakly foliated, fine grained; contains quartz, sodic oligoclase, perthitic microcline, and accessory hastingsite, hornblende, chloritized biotite, sphene, magnetite, apatite, and locally abundant secondary epidote. Dated at 447±4 Ma (site O–12)

Oo2–6b **Biotite granodiorite, trondhjemite, and quartz diorite**—North end of Jefferson batholith (index 63); identification uncertain in Success lobe of Jefferson batholith (index 64). Light-gray, strongly foliated, medium-grained trondhjemite grading to gray to pink granodiorite and dark-gray quartz diorite. Granodiorite locally contains quartz phenocrysts as large as 1 cm across near northeastern contact, which may represent roof of pluton. Trondhjemite composed of quartz, oligoclase, and about 5–10 percent biotite and muscovite. Dated at 454±5 Ma (site O–10); considered approximately coeval with biotite granodiorite (Oh2b) of Whitefield pluton, tentatively dated at about 458 Ma (site O–2)

**Highlandcroft Plutonic Suite (Silurian?, Llandoverian?, and Ordovician, Cincinnatian to late Whiterockian)**—Discordant, epizonal to mesozonal plutons exposed northwest and north of axial trace of Bronson Hill anticlinorium (fig. 4). Metamorphosed, massive to strongly foliated; range in composition from granite to local diorite or gabbro. Isotopic data indicate emplacement in the range of about 452–440 Ma (sites O–3 to O–6, O–9, O–11), in earliest Silurian(?) and Ordovician (Cincinnatian or Mohawkian) time

**Silurian (Llandoverian) or Ordovician (late Cincinnatian) rocks**

SOh2f **Aplitic granodiorite and quartz porphyry**—Catheart Mountain pluton (index 3) and unnamed body at Number 5 Mountain, Spencer Lake qd, ME. Catheart Mountain pluton intrudes Attean pluton (index 2) and is unconformably overlain by strata of Lower Devonian Seboomook Group (Dss); typically sheared, hydrothermally altered, light-rusty-weathering, aplitic biotite granodiorite, probably subordinate granite, and quartz porphyry; quartz porphyry contains subhedral phenocrysts of quartz. Host to copper-molybdenum porphyry deposit; zones of propylitic, sericitic-silicic (phyllic), and alteration recognized. Muscovite of muscovite-molybdenite greisen dated at 441±8 Ma (K-Ar) and 447±10 Ma (Rb-Sr) (site O–6). At Number 5 Mountain, not extensively altered; composed of fine-grained quartz, plagioclase, and probably minor potassium feldspar, and scattered phenocrysts of biotite 1 mm across and ovoid phenocrysts of feldspar and quartz 5 mm across; cuts rocks of Chain Lakes massif; grades to granite of Attean pluton

SOh1f **Aplitic granite and quartz porphyry**—Sally Mountain pluton (index 4). Similar to rocks of Catheart Mountain pluton (index 3), but more silicic, possibly owing to more intense silicification. Probably not comagmatic with Catheart Mountain pluton (Ayuso, 1989)

**Ordovician (Cincinnatian and Mohawkian) rocks**

Oh1–2h **Hornblende-biotite granite to granodiorite**—Skinner pluton (index 6), small queried faulted body east of Cupsuptic pluton (index 16), and northern part of Lost Nation pluton (index 53). Rocks of Skinner pluton similar to Attean pluton (index 2), but less porphyritic and typically contain less potassium feldspar. Queried body near Cupsuptic pluton mapped previously as Ordovician granodiorite, but modes listed by Harwood (1973, table 4) indicate common hornblende-bearing granite; strongly fractured and veined; might be Devonian. North end of Lost Nation pluton dated at 442±4 Ma (site O–11); light gray to pinkish gray, medium to coarse grained; locally contains feldspar phenocrysts; retrogressively metamorphosed, but contains hornblende where least altered; contains abundant accessory euhedral sphene. Contact with intermediate to mafic rocks of southern part of Lost Nation pluton (Oh2–9h) mapped on basis of aeromagnetic data

Oh2–9h **Hornblende-bearing granodiorite to diorite or gabbro**—Southern part of Lost Nation pluton (index 53), dated at 442±4 Ma (site O–11). Foliated, medium grained, variably medium gray to almost black; variably retrogressively metamorphosed to greenschist facies; euhedral sphene an abundant accessory mineral. Composition extremely variable, but relationships of rocks of different composition are not known. Northern contact against more felsic rocks of pluton drawn on basis of aeromagnetic data

Oh1hx **Porphyritic hornblende-biotite granite**—Attean pluton (index 2), dated at 443±4 Ma (site O–5). Typically massive to weakly foliated, pink and green, medium- to coarse-grained, two-feldspar granite containing abundant phenocrysts of potassium feldspar and 5–10 percent total hornblende, biotite, and chlorite. Strongly sheared within 3 km of Thrasher Peaks fault (TPF)

Oh2h **Hornblende-biotite granodiorite**—Highlandcroft pluton (index 58), dated at 450±5

Ma (site O–3). Foliated, greenish gray, medium grained. Although data reported by Billings (1937, tables 10, 19) suggest composition is quartz monzonite (Streckeisen), more recent studies indicate composition is granodiorite (Lyons, 1964; Pogorzelski, 1983). Variably altered; where relatively fresh, contains several percent of hornblende and green biotite; alteration products are chlorite, sericite, and calcite. Intrudes and chilled against basaltic facies of Ordovician Ammonoosuc Volcanics (Oab); unconformably overlain by Silurian Fitch Formation (Sf)

Oh1–2x **Porphyritic granite to granodiorite**—Adamstown pluton (index 35), dated at 452±4 Ma (site O–4). Foliated, weakly to strongly metamorphosed, light-gray, coarse-grained, porphyritic, two-feldspar granite to granodiorite; typically contains blocky phenocrysts of microcline 1–2 cm long. At low metamorphic grade, contains chlorite, epidote, and sericite or muscovite; in sillimanite zone, contains well-crystallized metamorphic biotite and muscovite

Oh2b **Biotite granodiorite**—Whitefield pluton (index 61). Lead isotope data ($^{207}Pb$-$^{206}Pb$) for zircon crystals suggest a crystallization age of about 458 Ma (site O–2). Strongly foliated, pinkish gray to dark gray, variably fine to medium grained; commonly contains minor muscovite, and locally contains hornblende. Average composition uncertain; probably granodiorite, but with much variation. Part of pluton that lies southwest of Alderbrook pluton (index 60) is less magnetic and probably more potassic than northeastern part, as indicated by aeromagnetic data and one chemical analysis (Billings, 1937, table 19, sample No. 15); intrusive contact of this body against Ordovician Ammonoosuc Volcanics (Oa) exposed on southeast side of Eustis Hill, Littleton qd; same body is intruded by the Scrag Granite (Oo1b) as used by Billings (1937), dated at 456±3 Ma (site O–8)

**Ordovician (Ordovician, late Whiterockian?) rocks**

Oh1b **Biotite granite**—Cambridge Black pluton (index 38), tentatively dated at 468±3 Ma (site O–9). Foliated, pink, medium grained, equigranular; contains quartz and two feldspars, and a few percent of biotite and secondary muscovite. Foliation crosses the pluton and is concentric to dome cored by the Success lobe of Jefferson batholith (index 64)

**Chickwolnepy intrusions[3] (Ordovician; late Whiterockian)**—Metamorphosed tonalite, gabbro, and sheeted diabase exposed at and near Chickwolnepy Stream, Milan qd, NH (index 39). Considered comagmatic with lower part of Ordovician Ammonoosuc Volcanics; inferred to represent a center of incipient extensional spreading diagonal to regional tectonic trend. Age assigned on basis of a U-Pb zircon age of 467±3 Ma (site O–7) obtained from porphyritic hornblende-biotite tonalite

Oc3Ah **Hornblende-biotite tonalite**—Gray, foliated, medium grained; contains several percent of metamorphic hornblende and biotite

Oc3Ahx **Porphyritic hornblende-biotite tonalite**—Foliated, medium to coarse grained, gray; contains equant quartz phenocrysts as much as 1 cm across, and locally strongly flattened quartz phenocrysts. Dated at 467±3 Ma (site O–7). Northwestern body, tentatively included in Chickwolnepy, is metamorphosed in northwestern part to greenschist-facies rock containing chlorite, sericite, and calcite. Where metamorphosed at higher grade to southeast, contains several percent of metamorphic biotite and hornblende

Oc9B **Gabbro and sheeted diabase**—Gabbro is dark-olive-green, variably massive to gneissic, medium- to coarse-grained hornblende-plagioclase amphibolite; commonly contains irregular dikelets of aplitic trondhjemite or tonalite, and autobreccia having a tonalitic or trondhjemitic matrix. Diabase is generally fine-grained hornblende-plagioclase amphibolite, commonly chilled against adjacent diabase or gabbro; relatively thick dikes may contain subparallel dikelets of aplitic trondhjemite; blebs of aplitic trondhjemite also common within chill zones of relatively large dikes. Dike-in-dike relations common and more than two generations of diking recognized in many outcrops

Oj3A **Tonalite of Joslin Turn pluton and related bodies (Ordovician; late Whiterockian)**—Weakly to strongly foliated, medium-grained, granophyric tonalite (index 57); retrogressively metamorphosed to greenschist facies and widely hydrothermally altered, particularly at north end of main body, where rock contains disseminated pyrite and chalocpyrite. Age assigned on the basis of a U-Pb zircon determination at 469±2 Ma (site

O–13); considered to be comagmatic with felsic volcanic rocks of lower part of Ordovician Ammonoosuc Volcanics (Oa)

**Boil Mountain Complex (Cambrian?)**—Exposed at south side of Chain Lakes massif (index 17). Metamorphosed ultramafic and mafic rocks and associated trondhjemite interpreted as the plutonic member of an ophiolite body (Boudette, 1982) that formed in vicinity of a subduction zone (Coish and Rogers, 1987). Boil Mountain Complex and volcanic rocks of the overlying Cambrian(?) Jim Pond Formation (Ꞓj) are a thin (3 km or thinner), but nearly complete, ophiolite sequence that lacks only sheeted dikes (Boudette, 1982). Rocks of the complex are strongly sheared and altered in southwestern exposures, less so toward the northeast. Trondhjemite of complex dated at about 520 Ma (site Ꞓ–1), but with large uncertainty. On this basis a Cambrian(?) age is here assigned to the Boil Mountain Complex; an Ordovician age, though unlikely, is not ruled out. Structurally overlies rocks of Chain Lakes massif, on a sharp surface of inferred Penobscottian tectonic ramping

Ꞓb **Boil Mountain Complex, undivided**—Shown only in section *A–A′*

Ꞓb3B **Trondhjemite**—White, chalky weathering, massive to foliated, equigranular to porphyritic; contains quartz phenocrysts as much as 7 mm across, and smaller plagioclase phenocrysts set in a fine- to medium-grained matrix of quartz and plagioclase largely altered to sericite and calcite, and a ferromagnesian silicate mineral altered to chlorite. Dated at about 520 Ma (site Ꞓ–1)

Ꞓb9u **Gabbro, epidiorite, and ultramafic rocks**—Where least deformed, can be divided into two members (not divided on map). Lower member composed of layered antigorite-bearing serpentinite (altered harzburgite and dunite) and metapyroxenite; upper member composed of epidiorite gradationally overlain by metagabbro, autobreccia, and minor pyroxenite; autobreccia contains epidiorite fragments in a calcic trondhjemite matrix. Upper member is intruded by trondhjemite, and is gradationally overlain by pillow basalt member of Cambrian(?) Jim Pond Formation (Ꞓjb)

## STRATIFIED METAMORPHIC ROCKS

[As shown by the metamorphic zones (fig. 4), the northern part of the area is mainly a greenschist-facies terrane in which plutons are surrounded by contact metamorphic aureoles, whereas the southern part of the area is an amphibolite-facies terrane in which there are no obvious aureoles. Except where the stratified rocks have been converted to migmatitic gneiss, bedding is typically well preserved and protolith compositions are obvious from mineral compositions. In order to emphasize their original stratigraphic character, these rocks are described mainly in terms of protolith compositions such as metamorphosed shale, sandstone, conglomerate, and so forth]

### Connecticut Valley trough

[Rock sequences northwest of the Monroe–Foster Hill–Thrasher Peaks line (fig. 3, M–F–T). Includes Silurian rocks of the Second Lake rift, which compose the Piermont-Frontenac allochthon, and overlying Lower Devonian parallochthonous to autochthonous rocks, interpreted to have accumulated over the allochthon during (parallochthonous) and after (autochthonous) transit.[4, 7] Silurian rocks of the allochthon are grouped into the western rift sequence (fig. 3, Srw), and the Piermont sequence (fig. 3, Srp)]

*Lower Devonian parallochthonous to autochthonous rocks*

Dg **Gile Mountain Formation (Lower Devonian?)**—Main body. Mainly gray to black pelitic phyllite or schist abundantly interbedded with graded metagraywacke, minor impure quartzite, grit, and local calcareous beds. Repeated graded beds common. Members include the Meetinghouse Slate Member (Dgm), possibly below the main body, and the volcanic and sedimentary member. Thickness uncertain, but probably more than 2,000 m. Conformably underlain by Waits River Formation (Swr)

Previously considered to be Early Devonian in age, on basis of Emsian plant fossils recovered from Compton Formation (Dco) in Quebec (Hueber and others, 1990; Hatch, 1991). Age assignment here changed to Early Devonian(?), because recent mapping indicates that Gile Mountain and Compton Formations are not coextensive across Vermont-Quebec border, as formerly believed (Doll and others, 1961; St. Julien and Slivitsky, 1987). Instead, these two formations are shown on this map to be separated by a belt of gray pelitic phyllite and associated grit assigned to Ironbound Mountain Formation (Dsi, Dsih). Ironbound Mountain Formation is conformably overlain by Compton Formation, but it is not known whether Ironbound Mountain is overlain or underlain by Gile Mountain Formation, as shown by queried Ironbound Mountain–Gile Mountain contact in Averill qd, VT; additional mapping is needed here. Correlation of Gile Mountain and Compton Formations is justified only if Gile Mountain Formation of this area is conclusively demonstrated to be underlain by Ironbound Mountain Formation; otherwise Gile Mountain, with possible exception of Meetinghouse Slate Member, must be coeval with Silurian Frontenac Formation. For reasons given in description of Meetinghouse Slate Member (Dgm), Gile Mountain and Compton Formations are here tentatively interpreted to be approximately coeval, in accord with previous interpretations; Meetinghouse Slate Member, however is here considered to occur below, rather than above (Hatch, 1988b), main body of Gile Mountain Formation

Dgm **Meetinghouse Slate Member**—Mainly interlaminated dark-gray pelitic slate or phyllite containing greatly subordinate thin graded laminations of metasiltstone and metasandstone, sparse lenses of volcaniclastic grit, and locally abundant felsic volcanic rocks, mapped separately (Dgmv). Unit distinctly more pelitic than typical rocks of main body (Dg) and is lithologically similar to Ironbound Mountain Formation (Dsi), exposed onstrike to northeast. Hatch (1988b) proposed that the member represents uppermost part of Gile Mountain Formation on basis of graded bedding seen by him south of map area. This relationship is not proven, however, because Gile Mountain–Meetinghouse contact is difficult to define, and because graded beds are not always easily interpreted (see Hatch, 1988b, fig. 6). On this map, member is tentatively shown to occur below main body of formation on basis of remarkable similarity between member and Ironbound Mountain Formation. Under this interpretation it is easier to reconcile highly pelitic character of member with upward-coarsening character of Lower Devonian sequences exposed elsewhere in map area. Meetinghouse Slate Member, for example, is compositionally similar to pelitic lowermost part of Littleton Formation near Littleton, NH, and it strongly resembles Ironbound Mountain and Carrabassett Formations, both highly pelitic basal units of Seboomook Group, respectively just northwest of Boundary Mountains anticlinorium and in Central Maine trough. Member probably less than 500 m thick in Littleton qd, but truncated by Monroe fault

Dgmv **Volcanic facies**—Eric and Dennis (1958, p. 24) reported occurrence of a few isolated lenses of fine-grained rhyolitic tuff in Meetinghouse Slate Member, and, at an abandoned quarry, tuff-matrix breccia. Quarry is at elevation of about 1,250 ft, 1 mi southwest of Stiles Pond; as observed by R.H. Moench (May 25, 1993), the volcanic rocks are exposed at a prominant face in quarry, where they form a 6-m-thick sequence of at least two felsic flows. The flows are unfoliated, internally massive, fine-grained probable dacite; a thin section revealed about 20 percent of biotite and sparse sericite, set in matrix of complexly intergrown quartz and feldspar. A flow boundary, exposed at the face, shows strongly amygdalloidal felsite that contains angular clasts of laminated sedimentary rock ripped from a thin underlying volcanic sedimentary layer that covers next underlying flow; this sequence tops northwest

Dgv **Volcanic and sedimentary member**—Metamorphosed sedimentary rocks of main body sparsely to abundantly interstratified with layers and lenses of hornblende-plagioclase amphibolite interpreted as metamorphosed basalt flows and tuff, and sparse white felsic gneiss and gray biotite gneiss interpreted as metamorphosed rhyolite tuff

Dco **Compton Formation (Lower Devonian; Emsian, Siegenian?, and Gedinnian?)**—Inferred PQ equivalent of Gile Mountain Formation (Dg). Mainly interbedded gray pelitic slate and metasandstone or metagraywacke; separable into three facies (not shown): metasandstone containing interbeds of slate and metalimestone, interbedded slate and metasandstone, and predominant slate or argillite. In Indian Stream qd, thinly interbedded gray phyllite and calcareous metasiltstone of lower part of Compton is gradationally underlain by Ironbound Mountain Formation (Dsi), and minor amounts of calc-silicate rock and quartzite. In PQ, conformably underlain by Silurian(?) Ayers Cliff Formation (Sa). Locally contains Lower Devonian (Emsian) plant fossils (Hueber and others, 1990). Because the fossils occur well above the top of the underlying Ayers Cliff Formation, the lowest beds of the Compton might be Silurian in age. Thickness unknown, probably more than 1 km

**Seboomook Group (Lower Devonian)[5]**

Dsu **Upper shale and sandstone**—Cyclically interbedded, fine-grained, graded metasandstone, metasiltstone, and gray slate; metasandstone beds typically 10–15 cm thick, ranging from 2 cm to 2 m thick. Thickness probably greater than 1 km northeast of Penobscot Lake qd, ME, but uncertain. Contact with underlying Ironbound Mountain Formation (Dsi) not exposed, but inferred to be abruptly gradational

Dsi **Ironbound Mountain Formation**[6]—Main body. Type area is in Penobscot Lake and Long Pond qds, ME. Previously mapped as several other units, for example Compton Formation in PQ (St. Julien and Slivitsky, 1987); Gile Mountain Formation in Averill, VT, and Dixville, NH, qds (Hatch, 1963; Myers, 1964); Seboomook Formation in Second Connecticut Lake and Arnold Pond qds, NH-ME (Green, 1968; Harwood,1973); Kidderville Formation in Dixville qd, NH (Hatch, 1963); Littleton Formation in Guildhall qd, VT (Johansson, 1963). In southern part of Penobscot Lake qd, ME, southwest to Spider Lake pluton (index 7), main body composed mainly of gray and locally greenish-gray, faintly bedded pelitic slate. Beds average about 10 cm thick, some faintly graded; commonly have poorly graded laminations of metasiltstone at lower contacts. Locally contains unmapped conglomerate having round clasts of slate, metasandstone, and uncommon metabasalt supported by a matrix of dark-gray slate. Grenier Ponds Grit Member (Dsig) exposed locally east of Ironbound Mountain, and widely exposed in strike belt of Big Grenier Pond, 25 km to northwest. In ME, NH, PQ, and VT, southwest of Spider Lake pluton, several unnamed volcanic or volcanic-related members, lenses, and intrusions assigned to the formation are mapped separately. In Indian Stream qd, NH, also contains thinly interbedded dark-gray to black phyllite, feldspathic metasandstone, grit, and, in upper part, gray slate containing scattered feldspar clasts. Maximum estimated thickness about 900 m. Contact with underlying sedimentary and basaltic members of Frontenac Formation (Sfr, Sfrb, Sfrws) of western rift sequence is conformable; contact with underlying rocks of Piermont sequence varies from conformable to probably unconformable. Interpreted to have accumulated over Silurian rocks of Piermont-Frontenac allochthon while in transit

Dsie **Euxinic shale member**—Previously mapped as Dixville Formation (name not used in this publication[4]), within core of an anticline in Dixville qd, NH (Hatch, 1963); recently shown to conformably overlie the felsic volcanic member (Dsif), in a faulted syncline. Rusty-weathering, graphitic-sulfidic schist sharply interbedded with tuffaceous metasandstone (or felsic metatuff) and laminated metachert. Probably at least 100 m thick, but upper contact not exposed; contact with underlying felsic volcanic member (Dsif) is conformable

Dsif **Felsic volcanic member**—Mapped in a southern belt and a northern belt between Deer Pond (DPF) and Thrasher Peaks (TPF) faults. Southern belt extends about 30 km northeast from a point just west of Dixville Notch, NH. Previously mapped as part of Kidderville Formation in Dixville qd (Hatch, 1963; name not used in this publication[4]), and as unnamed Silurian or Devonian volcanic rocks in Errol and Second Connecticut Lake qds (Green, 1964, 1968). Typically contains chalky-weathering, very thick, massive beds of feldspar crystal- and lithic lapilli- and ash-metatuff, feldspathic grit similar to that of Grenier Ponds Grit Member (Dsig), and sparse to abundant gray slate. Graded bedding common; locally contains chaotic mixtures of metatuff and gray metamudstone interpreted as conglomeratic mudflow deposits. Tongues northeastward into gray slate of this formation. Probable maximum thickness about 500 m; upper, lower, and lateral contacts are gradational. Northern belt extends nearly 20 km from Prospect Mountain, NH, to Thrasher Peaks, ME, where it hosts probable volcanogenic sulfide deposits. At Prospect Mountain, composed of about 600 m of felsic metatuff breccia; here previously mapped as felsic tuff breccia within Seboomook Formation (Green, 1968). Extends discontinuously to Thrasher Peaks, where tuff breccia is interstratified with rhyolitic metatuff and gray and black slate of this formation, and is probably underlain by basaltic to andesitic member (Dsib). Combined thickness of felsic and basaltic volcanic and conglomerate members at Thrasher Peaks nearly 1,000 m. This volcanic sequence was previously mapped as part of Magalloway Member of Ordovician Dixville Formation (Green, 1968; name not used in this publication[4]), and later as part of the Cambrian Jim Pond Formation (Moench, 1984); for justification of changes see Moench (1990)

Dsib **Basaltic to andesitic member**—Massive and pillowed basaltic to andesitic greenstone flows, lapilli tuff, and small probable feeder plugs exposed 5–10 km southwest of

Magalloway Mountain, NH, and pillowed, massive basaltic flows and agglomeratic basaltic greenstone, and massive, unbedded polymictic basaltic conglomerate on Thrasher Peaks, ME. The conglomerate contains blocks and subangular to rounded cobbles as large as 20 cm of greenstone and subordinate vein quartz, slate, metagraywacke, and metafelsite in matrix of feldspathic metasandstone and gray metasiltstone; previously mapped as infolded outliers of Silurian conglomerate unconformably overlying pre-Silurian rocks (Green, 1968), but here considered predominantly mafic volcanic conglomerate associated with adjacent basalt of member

Dsig **Grenier Ponds Grit Member[6]**—Penobscot Lake and Sandy Bay qds, at PQ border. Thickly interbedded light-gray lithic sandstone and feldspathic grit, commonly containing blocky feldspar grains, and about equal amounts of gray pelitic slate. Slate that intervenes between grit and sandstone beds is similar to that of type Ironbound Mountain Formation (Dsi). Unit considered equivalent to grit lenses at Halls Stream (Dsih). Minimum thickness of member about 600 m

Dsih **Grit lenses at Halls Stream**—Lenses in Indian Stream and Averill qds, NH and VT, of massive, poorly sorted, coarse-grained feldspathic grit or granule conglomerate containing angular to subrounded clasts of plagioclase, potassium feldspar, and quartz in matrix of fine-grained quartz and micas; beds commonly have ripup clots of black phyllite. Maximum thickness about 500 m; contacts with underlying gray slate of this formation gradational. Small remnant on Townsend Mountain and Mount Misery, northeast corner of Littleton qd, NH, contains a sequence about 10 m thick of thickly bedded, chalky-weathering quartz-feldspar metasandstone and grit of rhyolitic composition interpreted as reworked crystal tuff; basal bed of sequence channels into underlying gray slate of formation. Considered equivalent to Grenier Ponds Grit Member (Dsig)

Dsir **Rhyolite and microgranite intrusions**—Thrasher Peaks plutons (index 10) and other small bodies in Arnold Pond, Cupsuptic, and Second Connecticut Lake qds. Previously mapped as microgranite (Green, 1964); tentatively assigned to Ironbound Mountain Formation on the basis of evidence described by R.A. Cavalero (unpub. data furnished by Boise Cascade Corp., 1987) suggesting that microgranite bodies on Thrasher Peaks are rhyolite domes comagmatic with felsic volcanic rocks (Dsif). Typically light gray, massive, fine grained to aphanitic; composed of quartz, albite or oligoclase, micrographic orthoclase, biotite, and primary and secondary muscovite; contains accessory opaque minerals, zircon, tourmaline, epidote, apatite, garnet, and fluorite. Locally contains blotches and spherules of intergrown tourmaline and quartz as much as 5 cm across. Bodies at Thrasher Peaks dated at 414±5 Ma (site D–14) on basis of one concordant determination

Dsim **Magnetite-bearing shale and siltstone facies**—Exposed about 2 km west of Dixville Notch, Dixville qd, where previously mapped as part of Kidderville Formation (Hatch, 1963; name not used in this publication[4]), and on Burnside and Round Mountains, Guildhall qd, VT, where previously mapped as Littleton Formation (Johansson, 1963). Gray, massive to faintly bedded, magnetite-bearing slate or phyllite, commonly having scattered pink, garnet-rich laminations and lenses (coticule); in Guildhall qd, lower part of facies lacks magnetite. Locally contains layers of coticule-bearing interbedded quartz-magnetite-chlorite iron-formation (silicate iron-formation), locally, at Washburn Stream, Guildhall qd, containing several percent of disseminated chalcopyrite. Probable maximum thickness about 200 m; lower contact sharp, possibly an unconformity

Dsia **Altered slate near Deer Pond fault**—Green and greenish-gray slate of formation inferred to have been altered from gray to green during faulting

*Silurian rocks of Second Lake rift in Piermont-Frontenac allochthon*

**Western rift sequence**—Frontenac Formation; Tentatively includes Waits River and Ayers Cliff Formations, which might not be allochthonous

Swr **Waits River Formation (Silurian)**—In VT, at west edge of map area. Interbedded gray, fine-grained quartzose marble or calc-silicate rock; gray, calcareous and noncalcareous pelitic phyllite; and impure quartzite. Lower contact not exposed; thickness unknown, but probably more than 1 km. Previously assigned an Early Devonian age (Hatch, 1991). Here assigned a Silurian age based on a U-Pb zircon age of 423±4 Ma (a late Wenlockian to early Ludlovian number on fig. 3.4 of Harland and others, 1989) obtained from a felsic dike that intrudes the Standing Pond Volcanics (Aleinikoff and Karabinos, 1990), which overlies Waits River Formation in southeastern Vermont; Waits River Formation of that area can be no younger than about 423 Ma. Probably equivalent to Ayers Cliff Formation (Sa) in Quebec

Swrv **Volcanic and sedimentary member**—Metamorphosed calcareous sedimentary rocks of this formation sparsely to abundantly interstratified with lenticular bodies of black to dark-greenish-gray hornblende-plagioclase amphibolite interpreted as metamorphosed basalt flows and tuff, and gray, fine-grained biotite-quartz-sodic plagioclase gneiss interpreted as metamorphosed quartz keratophyre. Local premetamorphic alteration indicated by occurrence of gedrite(?), chlorite, and disseminated unidentified ore minerals (Woodland, 1965, p. 31) in some amphibolite bodies. Tentatively considered equivalent to Standing Pond Volcanics of southeastern Vermont

Sa **Ayers Cliff Formation (Silurian?)**—Probable PQ equivalent of Waits River Formation (Swr). Composed of calcareous slate and argillaceous to locally silty metalimestone. Lower contact not exposed; thickness unknown

**Frontenac Formation (Silurian; Pridolian?, Ludlovian, and Wenlockian)**—In belt of rock that includes type area, divided into a predominantly sedimentary facies (Sfr), a mixed sedimentary and volcanic facies (Sfrv), a proximal bimodal volcanic facies (Sfrx), and basalt lenses (Sfrb). Includes most sedimentary and volcanic rocks originally assigned to Frontenac Formation in Frontenac County, PQ (McGerrigle, 1935; Marleau, 1968) and in Second Connecticut Lake qd, NH (Green, 1968). In Arnold Pond qd, previously mapped as part of Dixville Formation (Harwood, 1969, 1973; name not used in this publication). In Dixville qd, NH, previously mapped as parts of Gile Mountain Formation and Kidderville Formation (Hatch, 1963; name not used in this publication). In PQ, rocks previously mapped as the formation of Clinton and the melange of Chesham (except euxinic metashale in the melange) by St. Julien and Slivitsky (1987) are assigned to Frontenac Formation (units Sfrb and Sfrv); euxinic metashale is Chevé's (1990) unit IV–2 of his formation of Chesham, which in this publication is tentatively assigned to Smalls Falls Formation (Ssf?). Frontenac Formation of the type belt is extended on this map into Guildhall and Percy qds, VT and NH. Formation is unfossiliferous; major part previously considered Early Devonian in age (Boucot, 1961; overview), but formation of Clinton and melange of Chesham previously considered Cambrian or Ordovician (St. Julien and Slivitsky, 1987). All units assigned to Frontenac Formation in this publication are considered Silurian in age (Wenlockian, Ludlovian, and Pridolian?) on basis of its conformable stratigraphic position below Lower Devonian Ironbound Mountain Formation, and Silurian U-Pb zircon ages of volcanic rocks within Frontenac obtained at sites M–1 (432±10 Ma), M–3 (418±4 Ma), and M–8 (≤430 Ma), and probably comagmatic intrusive rocks at sites S–1 (430±4 Ma) and S–2 (418±4 Ma). Although 432 Ma is late Llandoverian age (Harland and others, 1989), the margin of error overlaps early Wenlockian time, which is here considered a likely maximum age for Frontenac Formation because of evidence that Frontenac is underlain by basal rocks of Perry Mountain Formation (Spvs)

Sfr **Predominantly sedimentary facies**—Typically well-cleaved, matrix-rich, feldspathic arenite interbedded with dark-greenish-gray or gray slate or phyllite. In northern ME and adjacent PQ, metasandstone predominant; most beds 20 cm to 2 m thick, but bedding thickness varies greatly within single outcrops; poorly graded; common parallel laminations and rip-up slate clots; tops of beds may be scoured by next overlying bed. Typically contains abundant diabase sills and dikes (DS9). Probably at least 1 km thick. Contact with underlying basalt lenses of formation (Sfrb) are sharp and conformable; at one locality, metasandstone fills interstices around pillows at the top of underlying basalt. In northern NH and adjacent PQ and VT, metasandstone typically is less abundant. Unit considered coeval with Madrid (Sm), Smalls Falls (Ssf), and Perry Mountain (Sp) Formations of Piermont sequence. In Guildhall qd, VT, grades laterally with variably tuffaceous quartzite and shale of Perry Mountain Formation (Spt); locally contains thin lenses of black sulfidic slate interpreted as northwestern feather edge of Smalls Falls Formation, and overlying brown-weathering, weakly calcareous metasiltstone and metasandstone similar to much of Madrid Formation of Piermont sequence. Distinguished from Perry Mountain Formation of Piermont sequence by presence of well-cleaved arenite characteristic of Frontenac Formation and absence of matrix-poor quartzite characteristic of Perry Mountain Formation. Thickness unknown; probably greater than 1 km. In Guildhall qd, VT, lower and lateral contacts with Perry Mountain Formation are indefinite, but lowermost rocks of Frontenac Formation apparently grade downward into a thin tongue of Perry Mountain Formation that extends westward from the basal part of the main body of Perry Mountain. Extensive basalt lenses and proximal bimodal volcanic facies define Second Lake rift axis (fig. 3; SLRA) northeast of Dixville qd, NH

Sfrv **Mixed volcanic and sedimentary facies**—Exposed in PQ, northeast of Marble Mountain, in Dixville qd, NH, and at Guildhall-Percy qd boundary, NH. Interstratified felsic volcaniclastic graywacke, greenish-gray pelitic phyllite, fine-grained felsic metatuff and metabasaltic flows or tuff beds; commonly rusty weathering. Distinguished from mixed sedimentary and volcanic facies of Perry Mountain Formation (Spvs) by absence of quartzite beds. Considered a distal facies of proximal bimodal volcanic facies (Sfrx). In Dixville qd, conformably underlain on northwest by basalt lenses of this formation (Sfrb); conformably underlain on southeast by variably tuffaceous quartzite and shale facies of Perry Mountain Formation (Spt). Probable detrital zircon grains dated at about 500 Ma at site M–5

Sfrx **Proximal bimodal volcanic facies**—Mapped in an extensive belt northeast of Magalloway Mountain, NH, into PQ. Contains chalky-weathering, massively bedded felsic ash- and lapilli-metatuff; sharply interbedded felsic metatuff and metabasalt flows and tuffs; water-reworked tuffaceous metasandstone and green phyllite; and locally conspicuous fragmental metarhyolite, volcanic breccia, agglomerate and manganiferous iron-formation. Isotopically determined Silurian ages obtained at sites M–1, M–3, and M–8. Fragmental metarhyolite exposed at the west end of Rump Mountain, Second Connecticut Lake qd, NH, and on a knoll northeast of Moose Bog, Moose Bog qd, ME. Host to massive-sulfide deposit at Ledge Ridge (Moench, 1990). Measured thickness of member along knolls north of Moose Bog, Moose Bog qd, about 750 m; contact with underlying pillowed basalt of Frontenac Formation (Sfrb) in this area is sharp, conformable, and marked by thin layer of laminated ferruginous metasiltstone and chert. Structurally interpreted to lie within a faulted synclinal crease along the axis of the volcanic belt, which is broadly anticlinal; the crease is considered a remnant of a half graben valley along Second Lake rift axis (SLRA)

Sfrb **Basalt lenses**—Includes rocks mapped as Canada Falls Member by Marvinney (1986; name not used in this publication) in Penobscot Lake qd, ME, and basalt lenses in PQ, NH, and adjacent ME southwest to Gore Mountain plutons (index 43); separate bodies may not be stratigraphically equivalent. Has chemical characteristics of basalt erupted in regions undergoing tectonic extension (Chevé and others, 1983; Eisenberg and others, 1983; Ebinger, 1985; Marvinney, 1986; Moench, 1990 and references therein). In Penobscot Lake qd, composed of massive to pillowed basaltic greenstone interbedded with minor amounts of green slate. Maximum thickness may be more than 1,000 m, but lower contact not exposed. Farther south into NH, composed of basaltic greenstone flows, commonly pillowed, and basaltic greenstone tuff, agglomerate, breccia, and water-reworked mafic metavolcanic rocks; local cherty iron-formation near upper contact. Pyroclastic facies exposed west and southwest of Diamond Pond, and in Clinton River area, PQ, where host to volcanogenic massive-sulfide deposits of Clinton River area (Moench, 1990). Maximum thickness east of East Inlet pluton (index 12) about 2,000 m, but lower contact not exposed. Intruded by Silurian East Inlet pluton (index 12), dated at 430±4 Ma (site S–1); lower contact not exposed

**Western facies of Frontenac Formation (Silurian)**—Weakly metamorphosed sedimentary rocks exposed northwest of Perry Stream and Marie Petoch faults (PSF, MPF). Lacks recognized metavolcanic rocks

Sfrws **Shale and arenite member**—Composed mainly of rocks similar to those of eastern facies, but lacks volcanic rocks. Previously mapped as part of Gile Mountain Formation in Dixville (Hatch, 1963) and Averill (Myers, 1964) qds, NH–VT. Age based on conformable position below Lower Devonian Ironbound Mountain Formation (Dsi) and interpretation that unit is a nonvolcanic lateral facies of rocks of type belt. Metagraywacke beds that host cobbles containing possible fungus remains, having a range from Silurian (late Wenlockian) through late Devonian, in Indian Stream qd are probably no older than late Wenlockian (Hueber and others, 1990); a Devonian age, however, is not ruled out. Thickness unknown; probably more than 1 km, but lower contact not exposed

Sfrwg **Graded-bedded graywacke member**—Repeated graded beds of metagraywacke that range in thickness from 5 to 60 cm; each bed grades continuously to thinner beds of dark-gray or black phyllite; gradationally overlies typical undivided rocks of western facies (Sfrws). Forms lenses as much as 850 m thick

Sfrwh **Hornblende schist lenses**—Black to dark-greenish-gray hornblende-quartz schist; commonly contains small amounts of biotite, plagioclase, apatite, pyrite, magnetite, and garnet. Tentatively interpreted as water-reworked basaltic tuff. Maximum thickness about 75 m

Sfrwc **Calcareous member**—Exposed in Dixville qd, where previously mapped as Waits River Formation (Hatch, 1963). Interbedded gray, fine-grained quartzose marble or calc-silicate rock, gray, calcareous and noncalcareous pelitic phyllite, and dark-gray to black graphitic phyllite; calcareous rocks weather punky and brown. Estimated thickness in Dixville qd, NH, about 300–500 m (Hatch, 1963), but lower contact not exposed

**Piermont sequence**—Includes rocks previously assigned to Albee Formation by Billings (1956), Eric and Dennis (1958), Johansson (1963), Hatch (1963) and Green (1964, 1968), and rocks previously assigned to Dixville Formation by Hatch (1963) and Green (1964, 1968); these two names are not used in this publication. Formations of Piermont sequence are correlated with Silurian and Silurian(?) units of central Maine trough (fig. 3; CMT)

Sm **Madrid Formation (Silurian?; Pridolian? and Ludlovian?)**—Lenses, typically less than 60 m thick, of weakly calcareous, laminated and thinly bedded, purply-gray or brownish-weathering feldspathic metasandstone, phyllitic metasiltstone, and local felsite and basaltic greenstone, and thick beds of fine-grained feldspathic metasandstone containing lenses of calc-silicate rocks characteristic of Madrid Formation of central Maine trough (CMT). Mapped separately from Smalls Falls Formation at Townsend Mountain, Littleton qd, on Mud Pond Ridge (east of Mud Pond), Dixville qd, and on Round Mountain and Burnside Mountain, Guildhall qd. Conformably underlain by Smalls Falls Formation

Ssf **Smalls Falls Formation (Silurian; Ludlovian?)**—Main body. Mapped extensively in Milan, Errol, Dixville, and Second Connecticut Lake qds, NH, and in many small synclines or faulted synclines from Littleton qd to Moose Bog qd. In Dixville, Errol, and Second Connecticut Lake qds, previously mapped as Dixville Formation (Hatch, 1963; Green, 1964, 1968; name not used in this publication[4]). Elsewhere in NH previously mapped as part of Albee Formation (Billings, 1956; name not used in this publication); in Guildhall qd, VT, previously mapped as Partridge Formation (Johansson, 1963). Where queried in Clinton River area, PQ, previously mapped as unit IV–2 of formation of Chesham (Chevé, 1990). Typically very rusty weathering, dark-gray to coaly black, graphitic-sulfidic phyllite sharply interbedded with sparse to abundant feldspathic quartzite, and local grit; locally contains concretions of pyrrhotite as much as 1 cm across. Age based on correlation with graptolite-bearing rocks of unit in central Maine trough (eastern sequence); possibility that rocks are partly Pridolian or Wenlockian not ruled out. Thickness of main body variable, possibly locally more than 300 m, but rocks of main body occur above and below other units (Ssfb, Ssff, Ssfc, and Ssfv); maximum combined thickness of main body and other units as much as 800 m. In Littleton qd, formation apparently wedges out westward across quadrangle from as much as 250 m on Townsend Mountain to less than 10 cm west of Littleton qd boundary. Contact of Smalls Falls with underlying Perry Mountain Formation (Sp) sharp or abruptly gradational and conformable. Narrow belt of black slate mapped as Smalls Falls Formation in Moose Bog qd, ME, conformably underlain by felsic volcanic rock of proximal bimodal volcanic facies of Frontenac Formation (Sfrx)

Ssfv **Mixed volcanic and sedimentary facies**—West of Stratford Bog Pond and southwest to Round Mountain, Guildhall qd. Rusty-weathering, sulfidic, black phyllite and dark-gray to black, laminated and massive fine-grained feldspathic metatuff, lapilli metatuff, felsite, and flows and local tuff beds of basaltic amphibolite

Ssff **Felsic volcanic lenses**—In Second Connecticut Lake qd, near Magalloway Mountain, well-stratified, chalky-weathering felsic metatuff; maximum thickness probably less than 100 m. In Errol qd, white-weathering, thickly to thinly stratified rhyolitic metatuff, tuffaceous metasandstone and local felsic-lapilli metatuff; commonly contains manganiferous, garnet-rich laminations (coticule) and metamorphosed exhalative chert and cherty iron-formation. Lapilli metatuff dated at about 434 Ma (site M–2), but margin of error is large because of inheritance of much older radiogenic lead

Ssfb **Basalt lenses**—Percy qd north through Dixville and Second Connecticut Lake qds, NH. Massive and pillowed metabasaltic flows and tuff, and local mafic metasandstone near lower contact; commonly interstratified with laminated manganiferous metachert, some containing abundant garnet (coticule), and magnetite iron-formation. Previously mapped as Clear Stream Member of Dixville Formation (Green, 1964; names not used in this publication[4]). Maximum thickness about 500 m

Ssfc **Polymictic conglomerate lenses**—At Dummer Hill, Percy qd, NH, lens as much as 100 m thick of polymictic pebble and cobble metaconglomerate interstratified with basaltic amphibolite and cherty magnetite iron-formation; conglomerate beds massive to thickly stratified, locally graded; pebbles and cobbles rounded to angular, composed of varied volcanic and sedimentary rocks, granite, and gabbro supported by matrix of micaceous, quartzo-feldspathic volcaniclastic grit. Intertongues with basal 100 m of basaltic lens. At Mud Pond Ridge (east of Mud Pond), Dixville qd, poorly sorted metaconglomerate containing rounded boulders as much as 15×30 cm, supported by a matrix of sulfidic pelitic schist; clasts are dark- and light-gray quartzite, feldspar crystal metatuff containing blue quartz, and metadiabase

Smsf **Madrid Formation (Silurian?) and Smalls Falls Formation (Silurian), undivided**—Mapped in Littleton qd, NH. On south side of Foster Hill, about 40 m of black, pyritic slate containing minor quartzite and felsic metatuff assigned to the Smalls Falls is conformably overlain by about 50 m of brownish-gray-weathering, weakly calcareous, laminated slate and metasiltstone, tuffaceous metasandstone, and brown-weathering, calcitic, amygdalloidal greenstone assigned to Madrid. Smalls Falls Formation sharply but conformably underlain by variably tuffaceous quartzite and shale facies of Perry Mountain Formation (Spt)

**Perry Mountain Formation (Silurian; Ludlovian? and Wenlockian?)**—Previously mapped as part of Albee Formation[4] in northern NH (Billings, 1956; Green, 1964, 1968) and northeastern VT (Doll and others, 1961). Divided on this map into a quartzite and shale facies (Sp), a variably tuffaceous quartzite and shale facies (Spt), a mixed sedimentary and volcanic facies (Spvs), and hematitic siltstone lenses (Sph). Age based on conformable position below Smalls Falls Formation (Ssf), and above Rangeley Formation (Sr), and on field evidence that unit is a partial lateral facies of Frontenac Formation (Sfr). Total thickness variable from 300 m minimum west of Errol, NH, to locally at least 1 km elsewhere in Piermont sequence; contact with underlying gray to black phyllite and quartzite of Rangeley Formation (Sr) abruptly gradational and conformable

Sp **Quartzite and shale facies**—Sharply interbedded, pale-green or greenish-gray slate, phyllite, or schist and typically quartz-rich metasandstone; locally rusty weathering and pyritic. In contrast with the typically distal, planar-bedded quartzite and shale of the Perry Mountain of the central Maine trough (CMT), which is characterized by abundant bouma turbidite features and cross-laminations produced by extensive reworking by bottom currents, the Perry Mountain of the Piermont sequence is more proximal in sedimentary habit, characterized by more abundant lenticular-bedded, internally massive, poorly graded metasandstone beds that rarely show cross-laminations; thick quartzite beds locally have ripups derived from underlying shale. Unit inferred to grade laterally into variably tuffaceous quartzite and shale facies (Spt)

Spt **Variably tuffaceous quartzite and shale facies**—Similar to quartzite and shale facies, but containing abundant, chalky-weathering feldspathic quartzite and probable felsic tuff beds, as well as true quartzite beds, as shown petrographically by Hafner-Douglass (1986). Inferred to be transitional between quartzite and shale facies (Sp) and mixed sedimentary and volcanic facies (Spvs)

Spvs **Mixed sedimentary and volcanic facies**—Composed of rocks similar to variably tuffaceous quartzite and shale facies, and abundant rhyolitic tuff beds and flows, basaltic greenstone or amphibolite flows and tuff beds, and locally abundant rhyolitic dikes and sills. Variably nonrusty to rusty weathering and pyritic. Grades laterally to variably tuffaceous quartzite and shale facies. Distinguished from mixed sedimentary and volcanic facies of Frontenac Formation (Sfrv) by presence of quartzite. Silurian(?) U-Pb zircon ages obtained from metamorphosed rhyolitic tuffisite (412±2 Ma), and a rhyolite flow or sill (414±4 Ma) at site M–7

Sph **Hematitic siltstone lenses**—In Cupsuptic and Arnold Pond qds, red, hematitic slate, siltstone, and minor felsic tuff exposed at the boundary between underlying basalt of Frontenac Formation (Sfrb) and overlying variably tuffaceous quartzite and shale (Spt) of Perry Mountain Formation. Probably a few tens of meters thick; lower contact conformable, marked on Scotch Mountain, PQ, by red, ferruginous siltstone that fills interstices in underlying basalt pillows

Sr **Rangeley Formation (Silurian; Llandoverian)**—Previously mapped as part of Albee Formation in Moosilauke, Littleton, Guildhall, and Errol qds (Billings, 1937; Eric and Dennis, 1958; Johansson, 1963; Green, 1964), and as part of Kidderville Formation in Dixville qd (Hatch, 1963); previous names not used in this publication.[4] Typically rusty-weathering, dark-gray to black pelitic slate, phyllite, or schist sharply interbedded with poorly to conspicuously graded, thick to thin beds and laminations of rusty-weathering feldspathic quartzite. Polymictic conglomerate, quartz conglomerate, and rhyolite-rich conglomerate exposed near Piermont (fig. 3), and quartz conglomerate exposed in Milan qd; conglomerate unknown in intervening areas. In Littleton qd, locally contains several meters of punky, brown-weathering, weakly calcareous metasiltstone and metasandstone. In map area, most is probably coeval with Member C of Rangeley Formation (Src) of central Maine trough (CMT). Typically more strongly euxinic than Rangeley Formation of CMT. Age based on conformable position below Perry Mountain Formation, and on correlation with fossil-dated rocks of member C in Kennebago Lake qd. Near Piermont, NH, southwest of map area (fig. 3), conformably underlain by Greenvale Cove Formation (Sg); about 500 m thick in that area. Elsewhere in Piermont sequence, lower contact not exposed and thickness unknown

Bronson Hill–Boundary Mountains anticlinorium

[Includes Proterozoic or Cambrian, Cambrian(?), and Ordovician to Lower Devonian rock assemblages exposed southeast of the Monroe–Foster Hill–Thrasher Peaks line (fig. 3, M–F–T) (excepting the Ammonoosuc Volcanics exposed in the Coppermine Road window west of the line) and mainly northwest of the Silurian tectonic hinge (STH). The hinge separates thick Silurian basin deposits of the central Maine trough (CMT) from thin, commonly fossiliferous, Silurian (and some Lower Devonian) near-shore facies exposed in the anticlinorium. Whereas the Silurian basin deposits of the CMT are conformably underlain by the uppermost Ordovician deposits of the anticlinorium, the near-shore facies of the BHBM are unconformably underlain by more-deformed Ordovician and older rock assemblages of the BHBM. Broad groupings of rock assemblages of the anticlinorium are shown on figure 3]

Dl **Littleton Formation, main body (Lower Devonian; Emsian, Siegenian, and Gedinnian?)**—Exposed in Moosilauke and Littleton qds, NH. Predominantly dark-gray pelitic slate to schist, typically cyclically interbedded with graded feldspathic metasiltstone and metasandstone. Interpreted mainly as mud-silt-sand turbidites. On Walker Mountain, about 5 km west of Littleton, NH, Emsian fossils are 600 m and higher above lower contact, but on Dalton Mountain, Whitefield qd, Emsian fossils occur near lower contact of formation, in sandstone and conglomerate at Dalton Mountain (Dld). Unit also dated by fossils of late Siegenian and Emsian(?) age found in a limy sandstone lens (Dlls), near Kinsman

Notch, Mt. Moosilauke qd. Maximum exposed thickness about 1,400 m, but top of formation eroded. Contact with underlying Fitch Formation (Sf) either a conformity or a disconformity in Littleton qd; an unconformity in Whitefield qd

Dld **Sandstone and conglomerate at Dalton Mountain (Emsian)**—Gray sandstone and conglomerate at base of Littleton Formation on Dalton Mountain and on nearby Beede Mountain, Whitefield qd, NH. On Dalton Mountain, about 50 m thick; upper part composed of gray slaty sandstone containing late Early Devonian fossils at two localities (Boucot and Arndt, 1960); lower part, about 8 m thick, composed of thickly bedded, poorly sorted conglomerate and sandstone containing rounded to subangular pebbles as much as 6 cm across. Pebble types are quartzite, vein quartz, black chert, amphibolite, and felsite. On Beede Mountain, unit is probably about as thick as on Dalton Mountain; composed of massive, unsorted pebble to cobble conglomerate that is very thickly interbedded with sandy slate; conglomerate contains clasts of pale-green quartzite, vein quartz, black chert, gray slate, and coarse-grained feldspar. Lower contact is an angular unconformity. Faunal data indicate member is coeval with Tomhegan Formation (Dmto) (Boucot and Arndt, 1960; Boucot and Heath, 1969)

Dlls **Limy sandstone lens (Emsian? and upper Siegenian)**—Best exposed at fossil locality in Beaver Brook, which drains east side of Mount Moosilauke. Medium-bedded calc-silicate rock and calcareous quartzite interbedded with gray pelitic schist; fossils occur in a calc-silicate bed 5–10 cm thick. Unit a few meters thick; exaggerated on map to emphasize the fossil locality

Dlvs **Volcaniclastic sandstone member**—Northwest and northeast of Mount Moosilauke, Moosilauke qd, NH. Mainly laminated, light-purplish-gray, feldspathic, volcaniclastic metasandstone and metagraywacke; locally may contain gray pelitic schist characteristic of main body, or beds of calc-silicate rock. Grades laterally to mixed volcanic member (Dlv). Interpreted as resedimented deposits derived from volcanic rocks. Probably less than 200 m thick

Dlv **Mixed volcanic member**—Littleton and Moosilauke qds, NH. Interbedded gray pelitic schist, felsic crystal- and lithic-metatuff, metatuff-breccia, basaltic greenstone or amphibolite (locally pillowed) and volcaniclastic metagraywacke; thin layer east of Mount Moosilauke is mainly basaltic amphibolite. Maximum thickness about 250 m; present at a low stratigraphic level within main body of Littleton (Dl) and grades laterally into volcaniclastic sandstone member (Dlvs)

**Moose River Group (Lower Devonian)**

Dmto **Tomhegan Formation (Emsian)**—Exposed in Pierce Pond and Long Pond qds, ME. Main part is gray and rusty-weathering, massively bedded tuffaceous sandstone, slate, siltstone, and minor amounts of quartzite. Maximum estimated thickness about 1,800 m just northeast of map area. Considered a shallow marine deposit on basis of fauna; lower contact interpreted as a disconformity on basis of a faunal break (Boucot and Heath, 1969)

Dmtok **Kineo Volcanic Member**—Exposed in Long Pond and Pierce Pond qds, ME. Subaerial rhyolitic volcanic rocks of Grannys Cap and Cold Stream volcanic centers (Rankin, 1968, fig. 27–1); composed of weakly metamorphosed rhyolitic ash-flow tuff, flows, domes, volcanic breccia, grit, and conglomerate, and associated hypabyssal, garnet-bearing felsic intrusive rocks; largest intrusive bodies mapped separately as intrusive garnet rhyolite (Dmtoi). Includes Heald Mountain Rhyolite as well as Kineo Volcanic Member of Boucot and Heath (1969). Maximum thickness about 1,200 m. Lower contact an inferred disconformity

Dmtoi **Intrusive garnet rhyolite**—Previously mapped as either an unnamed garnet rhyolite or a garnet rhyolite assigned to Kineo Volcanic Member by Boucot and Heath (1969); now considered to be equivalent to Kineo Volcanic Member (Dmtok). Greenish-white-weathering, massive, irregularly fractured felsite, locally showing columnar jointing; contains about 5 percent garnet phenocrysts 2 mm in diameter and 10–15 percent white feldspar phenocrysts 2–3 mm long, set in a fine-grained matrix; locally shows spherulitic texture or flow banding. Bodies are variably concordant to sharply discordant

Dmt **Tarratine Formation, main part (upper Siegenian)**—Exposed in Long Pond and Pierce Pond qds, ME. Main part variably very thickly bedded (as much as 15 m) to laminated, dark-gray, quartz-rich metasandstone containing partings of slate and metasiltstone; metasandstone shows cross-laminations and ripple marks and has shelly lenses. Maximum thickness possibly as much as 3,000 m, but thins to feather edge by lateral gradation into unnamed shale and sandstone of Seboomook Group (Dss). Main part of Tarratine conformably (one locality) and disconformably (another locality) underlain by McKenney Ponds Limestone Member (Dmtmp). Where McKenney Ponds absent, main part unconformably underlain by Hobbstown Formation (Dhb), possible Lobster Mountain Volcanics (Ol?), and granitic rocks of Attean pluton (index 2, Oh1hx). Grades downward and laterally into unnamed shale and sandstone of Seboomook Group (Dss) through an interval of as much as 60 m

Dmtm **Misery Quartzite Member**—Thickly interbedded light-gray quartzite and sparse quartzite-pebble conglomerate, and dark-gray metasandstone, metasiltstone, and slate similar to main part of Tarratine. Quartzite beds compose 30–50 percent of unit; beds as thick as 1.5 m and strongly lenticular, locally cross-laminated. Maximum thickness 150 m; upper and lower contacts with main part of Tarratine Formation (Dmt) are gradational

Dmtmp **McKenney Ponds Limestone Member (upper Siegenian)**—Weakly metamorphosed, massive, white-weathering, fossiliferous, crystalline limestone; contains calcareous arkose near lower contact and slate and dark-gray sandstone near upper contact. On northwest side of McKenney Ponds, Pierce Pond qd, limestone of member grades laterally into arkose of lower part of Tarratine Formation (Dmt). Maximum thickness 60 m; lower contact is an unconformity

Dhb **Hobbstown Formation (Lower Devonian; upper Siegenian)**—Exposed in Spencer Lake, Pierce Pond, and Long Pond qds, ME. Main part, as much as 200 m thick, is coarse-grained meta-arkose and conglomerate. Lower unnamed member, as much as 60 m thick, is pebble to boulder roundstone conglomerate containing clasts of granite, felsite, calcareous siltstone, and limestone. Lower contact is an unconformity. Because Silurian (Pridolian?) fossils recovered from basal conglomerate might have been derived from underlying beds (Boucot and Heath, 1969), an Early Devonian (late Siegenian) age is favored

**Seboomook Group (Lower Devonian; Emsian, Siegenian, and upper Gedinnian?)**[5]

Dss **Shale and sandstone (Siegenian and upper Gedinnian?)**—Widely exposed in northwestern ME. Typically cyclically interbedded dark-gray slate and graded light-gray metasiltstone and metasandstone, in variable proportions; interpreted as repeated mud-silt-sand turbidites. Dated by fossils recovered at localities in Attean, Long Pond, Pierce Pond, and Spencer Lake qds. Maximum thickness possibly as much as 3,000 m, but thins to nil by lateral gradation into Tarratine Formation (Dmt). Contact with underlying limestone and slate at Little Big Wood Pond (Slbw) and conglomeratic sandstone near Crocker Pond (DSc), Attean qd, ME, gradational by interbedding; contact with all other underlying units either a disconformity or an unconformity

Dsch **Greenstone at Camera Hill**—Mapped in Spencer Lake qd, ME; previously mapped as Camera Hill Greenstone Member of Seboomook Formation (Boucot, 1961), but shown on this map as an informal unit within Seboomook Group. Lenticular bodies of porphyritic flows of intermediate(?) composition containing feldspar phenocrysts; locally vesicular near lower contact. Maximum thickness 120 m

Dsw **Well-bedded shale and sandstone**—Mapped in small area of Attean qd, ME. Cyclically interbedded graded metasandstone and dark-gray slate in about equal amounts; abundant metamorphosed sand dikes and other features of sediment liquefaction. Maximum thickness probably no greater than 200 m. Member conformably overlies pelitic and less conspicuously bedded rocks of shale and sandstone of Seboomook Group (Dss)

Dpk **Parker Bog Formation (Lower Devonian; upper Gedinnian)**—Exposed in Spencer Lake and Pierce Pond qds, ME. Weakly metamorphosed, interbedded light-gray pelmatozoan limestone and massive beds of flinty felsite, 1.5–3 m thick. Maximum thickness at least 60 m; exposed lower contact is faulted

Db **Beck Pond Limestone (Lower Devonian; upper Gedinnian)**—Small body in Spencer Lake qd, ME. Weakly metamorphosed, coarse quartzose limestone, stromatoporoid biostromes, and light- and dark-colored granite-boulder conglomerate; matrix is arkose. Maximum thickness 100 m; lower contact probably an unconformity

DSrf **Red shale and felsic tuff (Lower Devonian, Gedinnian?, or Silurian, Pridolian?)**—Exposed near Arnold River, Arnold Pond qd, ME. Lenses as much as 60 m thick of maroon to brick-red slate containing thin beds of gray metasiltstone and white felsic metatuff overlying white-weathering, massive to laminated, locally flow-banded felsic metatuff, 10–30 m thick. Unit conformably underlain by fossil-bearing calcareous rocks tentatively assigned to Fitch Formation (Sf?) and conformably overlain by unnamed shale and sandstone of Seboomook Group (Dss)

DScw **Undivided sedimentary rocks (Lower Devonian, Gedinnian?, and Silurian, Pridolian and Ludlovian?)**—Shown only in section *A–A′*. Includes conglomeratic sandstone near Crocker Pond (DSc), limestone and slate at Little Big Wood Pond (Slbw), and conglomerate at Wood Pond (Swp)

DSc **Conglomeratic sandstone near Crocker Pond (Lower Devonian, Gedinnian?, and Silurian, Pridolian?)**—Attean qd, ME. Previously mapped as unnamed conglomeratic sandstone (Albee and Boudette, 1972). Weakly metamorphosed, tan, thickly bedded, medium- to coarse-grained sandstone and conglomeratic sandstone containing clasts of quartz and subordinate feldspar and white mica. Maximum thickness about 100 m; intertongues with underlying limestone and slate at Little Big Wood Pond (Slbw) and with overlying rocks of Seboomook Group (Dss)

Slbw **Limestone and slate at Little Big Wood Pond (Silurian; Pridolian and Ludlovian?)**—Attean qd, ME. Previously mapped as unnamed limestone and slate (Albee and Boudette, 1972). Massive to slightly fissile, fine-grained limestone, and calcareous and noncalcareous slate. Maximum thickness about 200 m; lower contact an unconformity. Queried body on Thrasher Peaks fault (TPF) 10 km west of Little Big Wood Pond tentatively assigned to unit. Described by Westerman (1983, p. 89) as having an exposed length of 610 m and a maximum width of 62 m; composed mainly of brown-weathering, massive to locally thinly laminated limestone, underlain on southeast by breccia of limestone and granite along TPF, and overlain on northwest by gray phyllitic slate of Seboomook Formation ("Group" of this publication). Limestone body tentatively interpreted in this publication as a slice between two segments of TPF, because the limestone-Seboomook contact, apparently not seen in outcrop, follows a linear topographic depression (Westerman, 1983, p. 94)

Swp **Conglomerate at Wood Pond (Silurian; Pridolian or Ludovian)**—Attean qd, ME. Previously mapped as unnamed conglomerate (Albee and Boudette, 1972). Weakly metamorphosed, polymictic boulder and cobble conglomerate, conglomeratic sandstone, and feldspathic quartzite; contains subrounded clasts derived from underlying Attean and Sally Mountain plutons (index 2, 4) and blocks of calcareous sandstone. Maximum thickness 370 m; unit thins northward, where it grades laterally to limestone and slate at Little Big Wood Pond (Slbw). Lower contact is an unconformity

Sf **Fitch Formation (Silurian; Pridolian and upper Ludlovian)**—Littleton and Moosilauke qds, NH; locally contains Clough Quartzite (Sc) in lenses too small to show on map. At low metamorphic grade west of Ammonoosuc fault (AF), unit composed of metalimestone, marble, calcareous metasandstone, calcareous and noncalcareous slate, metagrainstone, and metapackstone; at one locality it contains boulders of granodiorite derived from underlying Highlandcroft pluton (Oh2h) (index 58). At higher metamorphic grade southeast of Ammonoosuc fault, unit is composed of commonly punky, brown-weathering, calcareous biotite- or phlogopite-schist and calc-silicate rocks. Locally contains wide variety of fossils (Billings and Cleaves, 1934; Harris and others, 1983). Thickness in Littleton area about 100–150 m. Contact with underlying Clough Quartzite (Sc) west of Littleton described as gradational, but a disconformity is inferred on basis of faunal data (Harris and others, 1983). Unit includes rocks tentatively assigned to Fitch Formation (Sf?) in Second Connecticut Lake, and Cupsuptic qds. Layer at northeast corner of Second Connecticut Lake qd composed of calcareous slate, about 150 m thick, containing lenses of sparsely fossiliferous limestone and conglomeratic limestone as much as 15 m thick. Body in same qd about 4 km northwest of Parmachenee pluton (index 13), composed of white to light-blue-gray crystalline and sandy limestone containing Silurian shells, probably Ludlovian; unconformably underlain by Magalloway Member of Jim Pond

Formation (Ꞓjm). Body just east of Parmachenee Lake, Cupsuptic qd, composed of weakly metamorphosed fossiliferous arenaceous and argillaceous limestone, about 210 m thick; fossils, in arenaceous limestone; contains Silurian (Pridolian) fossils; unconformably or disconformably underlain by rocks tentatively assigned to Clough Quartzite (Sc?)

Shm **Hardwood Mountain Formation (Silurian; Ludlovian? and Wenlockian)**—Exposed in Spencer Lake qd, ME. Weakly metamorphosed, mixed calcareous mudstone, siltstone, calcareous slate, minor but conspicuous limestone conglomerate, and sparse limestone and medium-grained sandstone. Maximum thickness about 900 m; lower contact an unconformity

Sul **Unnamed calcareous rocks (Silurian; Pridolian to Llandoverian)**—Exposed in Spencer Lake and Pierce Pond qds, ME. Dated by fossils found east of map area (Boucot and Heath, 1969). Composed of calcareous slate, sandstone, and limestone as much as 600 m thick, but cut by Squirtgun fault (SQF)

Sc **Clough Quartzite (Silurian; upper Llandoverian)**—In Littleton and Moosilauke qds, NH, composed of orthoquartzite, quartz pebble to granule conglomerate and smaller amounts of light-gray pelitic schist; clasts are vein quartz, quartzite, chert, and minor chips of schist. Onshore oxidizing sedimentary environment suggested by iron-rich metamorphic mineral assemblages along sedimentary partings (Rumble and Dickenson, 1986) and by stratabound deposits of massive and disseminated hematite iron-formation at south edge of Moosilauke qd. On Mount Clough, Moosilauke qd, quartzite is interbedded with amygdaloidal basaltic amphibolite. Dated by fossils found south of map area (Boucot and Thompson, 1963). Typically thinner than 100 m; lenticular bodies southwest of Littleton 0–120 m thick. Unconformably underlain by previously folded Ordovician metasedimentary and metavolcanic rocks of Partridge Formation (Op) and Ammonoosuc Volcanics (Oa) and by Ordovician and Silurian(?) plutons of Oliverian and Highlandcroft Plutonic Suites. Body tentatively assigned to Clough Quartzite (Sc?) just east of Parmachenee Lake, Cupsuptic qd, as much as 320 m thick; divided by an east-trending fault interpreted to coincide with a facies change from shoreline (or onshore) deposits on north side to slightly offshore on south side. North of fault: mainly quartz-pebble conglomerate containing clasts of quartzite, vein quartz, chert, and sparse feldspar and green phyllite; unconformably underlain by Hurricane Mountain Formation (Ꞓh). South of fault: mainly massive, thickly bedded, "vitreous" quartzite, locally interbedded with thin beds of dark-gray slate, interbedded in upper part with calcareous quartzite; lower contact locally marked by thin lens of polymictic conglomerate containing clasts of felsite porphyry, black chert, gray quartzite, granodiorite, and green phyllite in matrix of dark-gray argillite; largest clasts are 60 cm across; unconformably or disconformably underlain by argillite and tuff (Spla)

Sfm **Impure limestone at Flagstaff Mountain (Silurian; lower Wenlockian? and upper Llandoverian)**—Exposed on west slope of Flagstaff Mountain, Stratton qd, ME. Fossiliferous calc-silicate hornfels, approximately coeval with Clough Quartzite (Sc) and impure limestone and quartz conglomerate of Rangeley Formation (Srcl). Unconformably underlain by Dead River Formation (OꞒd)

Spla **Argillite and tuff near Parmachenee Lake (Silurian?; Llandoverian?)**—Cupsuptic qd, ME. Massive, greenish-gray argillite and subordinate well-bedded, dark- to light-gray argillite having thin, discontinuous beds of extremely fine-grained feldspar-rich metatuff. About 150 m thick; unconformably underlain by Hurricane Mountain Formation (Ꞓh)

Splq **Quartzite, argillite, and tuff near Parmachenee Lake (Silurian?; Llandoverian?)**—Cupsuptic qd, ME. Sharply interbedded quartzite and rusty-weathering, pyritic, pale-greenish-gray to tan phyllite, gradationally overlain by rusty-weathering laminated argillite, gray to black slate, felsite, felsic metatuff, and quartz grit. Thickness uncertain, probably less than 200 m; unconformably underlain by Hurricane Mountain Formation (Ꞓh). Rocks need further study

Sg **Greenvale Cove Formation (Silurian?; lower Llandoverian?)**—Correlated with rocks at type locality (Moench, 1969) on basis of lithologic similarity and position above Quimby Formation (Oq). West edge of Old Speck Mountain qd, ME. Slightly rusty weathering, light-gray to light-purplish-gray, laminated and thinly bedded feldspathic metasandstone, metasiltstone, and minor calc-silicate rock. Possibly 200 m thick, but upper contact not exposed; conformably underlain by Quimby Formation

**Quimby Formation (Ordovician; Cincinnatian)**—Exposed in several qds of Rangeley Lake area, ME, in Old Speck Mountain and Milan qd, ME, NH, and in Littleton and Moosilauke qds, NH. Rangeley Lake area: divided into graywacke member (Oqg), volcanic member (Oqv), which grades laterally with the graywacke member, and euxinic shale and graywacke member (Oqe); also garnet granofels at Loon Lake (Oql). Shale and graywacke member originally named the "shale member" (Moench, 1969). Total thickness about 1,000 m; conformably underlain by Partridge Formation (Op). Old Speck Mountain–Milan area: only euxinic shale and graywacke member (Oqe) exposed, about 100–300 m thick, but upper contact not exposed. Conformably underlain by laminated limestone and quartzite at Upton (Oul), which is disconformably or unconformably underlain by Ammonoosuc Volcanics; where laminated limestone absent, unit probably conformably underlain by Ammonosuc Volcanics. Littleton-Moosilauke area: divided into volcanic member, about 1 km thick (Oqv), and overlying euxinic shale and graywacke member (Oqe), about 200 m thick (but upper contact not exposed). Volcanic and shale and graywacke members originally mapped by Billings (1935) as part of Ammonoosuc Volcanics, and volcanic member previously mapped by Moench (1990, 1992) as upper member of Ammonoosuc. Near Swiftwater and Bath, NH, volcanic member conformably underlain by Partridge Formation (Op); about 2 km south of dam at Moore Reservoir, volcanic member unconformably underlain by Partridge Formation and Ammonosuc Volcanics. Originally assigned a Late Ordovician(?) age (Moench, 1969; Boudette, 1991). Here assigned an Ordovician (Cincinnattian) age on basis of U-Pb zircon determination of 444±4 Ma obtained from basal felsic metatuff of volcanic member at Bath, NH (site M–10); because this age is within error of the Ordovician-Silurian boundary of Tucker and others (1990; about 441 Ma), the possibility that uppermost beds of the Quimby Formation are Silurian is not ruled out

Oqe **Euxinic shale and graywacke member**—Rusty-weathering, dark-gray to black slate or phyllite interbedded with subordinate to subequal amounts of volcaniclastic metagraywacke; metagraywacke beds are typically massive or parallel laminated, abruptly graded at upper contacts. In Rangeley Lake area, polymictic conglomeratic metagraywacke occurs in two layers within lower part of member (Moench, 1971); each 30–100 m thick, thickly bedded, containing deformed pebbles of metamorphosed sedimentary and felsic volcanic rocks, chert, and vein quartz. Member about 700 m thick in Rangeley qd, incompletely exposed elsewhere

Oqg **Graywacke member**—Rangeley qd, ME. Thickly bedded volcaniclastic metagraywacke, locally conglomeratic, and minor rusty-weathering, dark-gray to black phyllite. Metagraywacke beds 15–150 cm thick, typically massive and abruptly graded at upper contacts; thickest beds commonly conglomeratic in lower part, having deformed small cobbles and pebbles of metasedimentary and metavolcanic rocks and small pebbles of vein quartz. About 300 m thick; unit locally grades laterally to volcanic member (Oqv)

Oqv **Volcanic member**—Small body exposed in northwest corner of Rangeley qd, composed of white-weathering, thickly bedded sodarhyolite tuff, massive to faintly flow-laminated sodarhyolite flows, and possible hypabyssal felsic intrusive rocks; probable maximum thickness about 200 m. Conformably underlain by Partridge Formation (Op); contact gradational. In Littleton and Moosilauke qds, composed mainly of very thickly to thinly stratified, white- to pale-orange-weathering, coarse-grained felsic metatuff and smaller amounts of felsic volcanic pebble to boulder conglomerate and possible pyroclastic flow deposits; also contains metabasalt flows and tuff, locally conspicuously graded; felsic tuff at base of member dated at 444±4 Ma (site M–10). North of Ammonoosuc fault (AF), predominantly felsic volcanic rocks of member divided into upper and lower layers separated by as much as 400 m of greenish-gray feldspathic phyllite interbedded with graded beds of tuffaceous metasandstone and scattered bodies of basaltic greenstone and minor amounts of felsic lapilli metatuff. Total thickness about 1 km. Conformably to unconformably underlain by Partridge Formation; near Swiftwater, Moosilauke qd, lower contact abruptly gradational by interbedding. Near Partridge Lake, Littleton qd, basal tuff bed locally contains ripups of black slate derived from underlying Partridge Formation; here, lower contact of unit apparently channels across the Partridge and into the Ammonoosuc Volcanics (Oa)

Oql **Garnet granofels at Loon Lake**—Undivided rocks of formation shown where metamorphosed to garnet granofels in Kennebago Lake qd, ME. Rusty-weathering, massive, medium- to coarse-grained granofels composed of 5–60 percent almandine garnet, as much as 50 percent andesine and subordinate biotite and quartz; garnet-poor rocks may contain hypersthene and amphibole or cordierite. Locally quarried for garnet (O'Connor, 1981). Interpreted as partially melted rocks of Quimby Formation near diorite and gabbro of Flagstaff Lake plutons (index 19; O'Connor, 1981); may include partially melted rocks of Greenvale Cove Formation (Sg)

Oul **Laminated limestone and quartzite at Upton (Ordovician; Cincinnatian)**—Old Speck Mountain–Milan qd boundary, ME, NH. Recognized by Milton (1968); previously mapped as calc-silicate layer at upper contact of Ammonoosuc Volcanics (Oa) (Moench and Pankiwskyj, 1988a). Laminated to thinly bedded, pink, white, green, and gray calc-silicate rock, impure marble, and local thick beds of calcareous quartzite. Maximum thickness about 8 m. Unconformably underlain by pyritic alteration facies of Ammonoosuc Volcanics (Oapa). Unit locally contains a small amount of scheelite; tentatively interpreted as subaqueous hydrothermal spring deposit on flank of a dying volcano

Ol? **Lobster Mountain Volcanics(?) (Ordovician; Cincinnattian?)**—Volcanic rocks tentatively correlated with Lobster Mountain Volcanics (Boucot and Heath, 1969, p. 56). Small body at Grace Pond, Pierce Pond qd, composed mainly of massive porphyry containing about 60 percent feldspar phenocrysts, 10 percent quartz phenocrysts, and 30 percent fine-grained matrix. Body at Johns Pond, Pierce Pond qd, composed of tan- to brown-weathering, graded and cross-laminated beds of volcaniclastic metasiltstone and metasandstone, andesitic volcanic rocks and volcanic breccia, and sparse conglomerate; might be a facies of Jim Pond Formation (Ꞓj). Small body northwest of Spencer Mountain, Spencer Stream qd, composed of poorly bedded, fine- to medium-grained feldspathic tuff containing 10 percent phenocrysts of feldspar and quartz. Contacts not observed; smallest bodies thought to be unconformably underlain by porphyritic granite (Oh1hx) of Attean pluton (index 2), and body at Johns Pond thought to be unconformably underlain by Hurricane Mountain Formation (Ꞓh). Possibly an eruptive facies of porphyritic granite of Attean pluton (index 2). Ordovician age determined by Neuman (1973)

**Ammonoosuc Volcanics (Ordovician; Mohawkian and upper Whiterockian)**—Represents volcanic core of Bronson Hill–Boundary Mountains anticlinorium, from Rangeley qd, ME, southwest through Moosilauke qd, NH. Divided into seven, mostly intergradational, facies. Age based on (1) early Mohawkian graptolites (Harwood and Berry, 1967; climactograptus bicornis) found in black slate of Partridge Formation (Op) in Cupsuptic qd, where Partridge intertongues with basaltic facies of Ammonoosuc (Oalb); (2) a late Whiterockian or early Mohawkian U-Pb zircon age of 461±8 Ma obtained from felsic metatuff at site M–9; (3) a Whiterockian age of 467±3 Ma obtained from tonalite of Chickwolnepy intrusions (Oc3Ah) (index 39; site O–7), interpreted to be comagmatic with early Ammonoosuc eruptions; (4) a Whiterockian age of 469±2 Ma obtained from tonalite of Joslin Turn pluton (Oj3A) (index 57; site O–13), also considered comagmatic with early Ammonoosuc eruptions. Maximum thickness possibly more than 1.5 km. Sharply but probably conformably underlain by Dead River Formation (OꞒd)

Oa **Undivided volcanic rocks**—Shown in section *F–F'* and locally on map

Oab **Basaltic facies**—In Cupsuptic, Oquossoc, and Rangeley qds, ME, previously mapped as part of Dixville Formation (Harwood, 1973; Guidotti, 1977; name not used in this publication), and unnamed mafic volcanic rocks (Moench and Pankiwskyj, 1988a). Dark-green, thickly layered, massive and pillowed basaltic greenstone, locally containing thin agglomerate beds; individual flows as much as 15 m thick. Maximum thickness about 1,500 m; intertongues with Partridge Formation (Op). In Milan and Old Speck

Mountain qds, previously included within Middle Ordovician mixed volcanic rocks (Moench and Pankiwskyj, 1988a); composed mainly of massive and pillowed basaltic amphibolite flows and dark-purplish-gray feldspathic biotite schist; about 500 m thick and tongues laterally into Partridge Formation (Op). In Littleton qd, composed of basaltic to andesitic metatuff, meta-agglomerate, pillowed metabasalt, fine-grained tuffaceous metasedimentary rocks, and minor amounts of felsic to intermediate metatuff; tongues southwest into proximal bimodal volcanic facies (Oax); thickness uncertain but probably more than 1 km. In Moosilauke qd, mainly composed of massive to thinly bedded basaltic greenstone or amphibolite, andesite metatuff, and white to dark-purplish-gray, thinly bedded feldspathic biotite schist interpreted as mafic volcaniclastic sandstone and siltstone; near contact with overlying Partridge Formation, commonly contains beds of laminated magnetite iron-formation and thinly bedded garnet- or anthophyllite-rich rocks of inferred volcanic-exhalative origin, and sparse small bodies of white, trondhjemitic quartz porphyry; exposed width in Moosilauke qd 0–200 m, but truncated by Foster Hill fault (FHF).

Oaf **Felsic volcanic facies**—Where exposed along southeast side of Ammonoosuc fault (AF), southwest of Littleton, NH, composed of light-gray to white-weathering, well-foliated, obscurely stratified felsic metatuff. Weathered outcrops characterized by scattered quartz "studs" 2–3 mm across. Maximum outcrop width about 700 m; considered part of volcanic center represented by proximal bimodal volcanic facies (Oax). Southwest of Lost Nation pluton (index 53), Whitefield qd, composed of rusty-weathering, somewhat better stratified quartz-muscovite schist, commonly containing quartz "eyes" 2–3 mm across; thought to represent a somewhat more distal facies of occurrence southwest of Littleton

Oax **Proximal bimodal volcanic facies**—In Old Speck Mountain qd and eastern part of Milan qd, composed of thickly stratified, metamorphosed felsic tuff, volcanic conglomerate and probable pyroclastic flow deposits, hypabyssal felsic intrusive rocks, basalt, and local sulfide- and magnetite-facies iron-formation. Hosts known massive sulfide deposits, as at Milan mine (not shown), near West Milan. Conformably underlain by basaltic facies (Oab) and grades laterally to volcaniclastic graywacke facies (Oag) and pyritic alteration facies (Oapa). In Littleton and Moosilauke qds, composed of metamorphosed basalt thickly interstratified with felsic tuff, volcanic conglomerate, agglomerate, and probable pyroclastic flow deposits; contains probable silicic domes and hypabyssal intrusive rocks, tuffaceous sedimentary rocks, and thinly bedded pyritic chert and magnetite iron-formation, which was mined locally for iron during the last century at Franconia iron mine, near south end of Sugar Hill pluton (index 86). Felsic volcanic components become less abundant relative to mafic components where unit grades laterally to basaltic facies (Oab). Felsic tuff dated at 461±8 Ma (site M–9). Small body exposed at northwest edge of Lost Nation pluton (index 53) composed of interstratified felsic metatuff, probably hypabyssal intrusive metafelsite, and small amounts of metabasalt; intrusive contact with Lost Nation pluton exposed 3 km S. 60° E. of summit of Sheridan Mountain, Guildhall qd

Oag **Volcaniclastic graywacke facies**—In Old Speck Mountain and Milan qds, composed of poorly stratified, rusty-weathering, garnetiferous two-mica schist interpreted as volcaniclastic metagraywacke, and sparse basaltic amphibolite. In Moosilauke qd at Bronson Hill and farther southwest, composed of nearly homogeneous, poorly stratified, medium-gray, fine-grained garnetiferous biotite-oligoclase-quartz gneiss; characterized by folded, paper-thin, biotite-rich laminations spaced 2–5 mm apart, probably produced by pressure solution along early cleavage; laminations warped over the crest of Bronson Hill, defining a large second-generation antiform. Southwest of Bronson Hill, unit contains variable amounts of basaltic amphibolite. In both areas, unit grades laterally to proximal bimodal volcanic facies (Oax)

Oas **Sedimentary and basaltic volcanic facies**—Mapped in Littleton and Whitefield qds, NH. In part previously mapped as Albee Formation (Billings, 1956; name not used in this publication) and later as Dead River Formation (Moench and others, 1987). Mainly thinly laminated light-gray feldspathic metasandstone to dark-purplish-gray volcaniclastic metagraywacke; locally contains rusty-weathering black phyllite similar to Partridge Formation and dark-grayish-green, magnetite-bearing phyllite having abundant pink, garnet-rich laminations (coticule). Locally interbedded with metabasalt and (or) metarhyolite. Probable maximum thickness about 250 m

Oai **Silicate iron-formation and quartz-kyanite gneiss**—Hampshire Hills, Milan qd, NH; lenticular body, as much as 300 m thick, composed mainly of massive to laminated quartz-magnetite-garnet-chlorite-biotite gneiss and minor amounts of feldspathic granofels. Contains a basal lens (maximum 40 m thick) of white, typically massive quartz-kyanite gneiss; locally faintly stratified and contains rounded, elliptical clasts of fine-grained quartz-kyanite granofels supported by gneissic matrix of same composition. Unit conformably enclosed in volcaniclastic graywacke facies (Oag); host to stratabound chalcopyrite-pyrrhotite deposit (not shown), along contact between quartz-kyanite gneiss and underlying rocks of volcaniclastic graywacke facies (Oag). Interpreted as mainly tuffaceous exhalite that accumulated in a sea-floor brine pool (Pyke, 1985)

Oapa **Pyritic alteration facies**—In Percy, Milan, and Old Speck Mountain qds, composed of very thickly to thinly stratified, variably pyritic, feldspathic quartz-muscovite schist interpreted as hydrothermally altered felsic metatuff. Also exposed, but too small to show on map, on both sides of Joslin Turn pluton (index 57), in Littleton qd, and in Coppermine Road window (fig. 3; CuRW)

Op **Partridge Formation (Ordovician; Mohawkian and upper Whiterockian)**—In Rangeley, Cupsuptic, and Oquossoc qds, ME, previously mapped as Dixville Formation (Harwood, 1973; Guidotti, 1977; name not used in this publication) and as unnamed black slate (Moench and Pankiwskyj, 1988a). Green and Guidotti (1968, fig. 19–3) correlated these rocks with Partridge Formation of Littleton and Moosilauke qds, NH, and unit is here assigned to the Partridge Formation. Mainly rusty-weathering, sulfidic, black slate interbedded with subordinate impure quartzite, sparse polymictic conglomerate; contains lenses of basaltic greenstone too small to map as basaltic facies of Ammonoosuc Volcanics (Oab). Upper 150 m is thinly interbedded rusty-weathering metagraywacke and black phyllite gradational to overlying graywacke member of Quimby Formation (Oqg). Maximum thickness about 1,800 m; intertongues with basaltic facies of Ammonoosuc Volcanics (Oab). In the Old Speck Mountain qd, ME, composed of rusty-weathering, graphitic-sulfidic schist interbedded with metagraywacke and minor amphibolite; intertongues with the basaltic facies in lower part of Ammonoosuc Volcanics. In Littleton and Moosilauke qds, composed mainly of rusty-weathering, black sulfidic slate and schist; locally contains graded beds of metasiltstone and metagraywacke, thin beds of felsic metatuff near upper contact, and intricately folded (probably slumped), white, sugary metachert near lower contact. Maximum thickness about 200 m; conformably underlain by facies of Ammonoosuc Volcanics (Oa) and conformably to unconformably overlain by volcanic member of Quimby Formation (Oqv). Age assigned on basis of early Mohawkian graptolites found in Cupsuptic qd (Harwood and Berry, 1967; *climacograptus bicornis*), and isotopic age data previously cited for Ammonoosuc Volcanics, with which the Partridge Formation intertongues. Sharply but probably conformably underlain by Dead River Formation (O€d)

Oqp **Quimby and Partridge Formations, undivided (Ordovician; Cincinnatian to Whiterockian)**—Mapped in northeast corner of Kennebago Lake qd, ME

O€d **Dead River Formation (Ordovician, Whiterockian to Upper Cambrian?)**—Previously mapped as Albee Formation (not used in this publication[4]) in Cupsuptic (Harwood, 1973) and Oquossoc (Guidotti, 1977) qds, ME, and in wide areas of northern NH (Billings, 1956; Green, 1968). Undated; assigned age based on position below Ordovician (Whiterockian and Mohawkian) Ammonoosuc Volcanics and above Cambrian(?) Hurricane Mountain Formation. Mainly thinly interbedded, greenish-gray slate or schist and typically subordinate quartzite or feldspathic quartzite. Quartzite beds typically graded; commonly have sharply defined "pinstripe-lamination" subparallel to bedding, probably produced by pressure solution. In Cupsuptic qd, ME, divisible into three members (Harwood, 1973), not shown separately on this map: (1) main body, as described above; (2) green slate and phyllite member containing thin veinlets of quartz and less than 10 percent quartzite, intertonguing with upper part of main body; and (3) red, maroon, and purplish-gray slate member containing 10–15 percent quartzite, intertonguing with lower part of main body. Quartzite-rich member east of Cupsuptic qd (O€dq), and member at Percy in Percy qd (O€dp) mapped separately. Southwesternmost known exposures of Dead River, in roof pendants and at borders of Lost Nation pluton (index 53) are atypical; composed of rusty-weathering, fine-grained quartzite interbedded with smaller amounts of rusty-weathering, dark-greenish-gray phyllite, which locally contains retrograde pseudomorphs after contact-metamorphic cordierite(?). About 700 m thick in Pierce Pond and Little Bigelow Mountain qds, ME, but upper part eroded; probably thicker along ME-NH border. Lower part of Dead River Formation grades laterally and downward to Aziscohos Formation (Harwood, 1973, p. 9), which can be considered a pelitic facies of Dead River Formation. Contact with underlying Hurricane Mountain Formation (€h) is conformable, variably sharp to gradational through about 30 m

O€dq **Quartzite-rich member**—In upper part of formation in Kennebago Lake qd, ME, and farther east. Contains thick beds of light-brown, commonly calcareous, feldspathic quartzite and quartzwacke that alternate with subordinate thinly interbedded greenish-gray slate and quartzite characteristic of main body. Maximum thickness probably about 200–300 m

O€dp **Quartzite and phyllite member at Percy**—Percy qd, NH. Feldspathic quartzite and local quartz-feldspar grit sharply interbedded with nearly equal amounts of dark-gray or dark-greenish-gray pelitic phyllite; phyllite is rich in chlorite at low metamorphic grade and in biotite and cordierite at high grade, owing to uncommonly high iron and magnesium contents (R.H. Moench, unpub. data, 1980, 1984). Locally rusty-weathering and pyritic, but not graphitic. Feldspathic quartzite beds typically 1–10 cm thick; abruptly graded at upper contacts. Metashale of unit probably derived from mafic volcanic rocks. Sharply separated from adjacent rocks of Perry Mountain Formation (Sp) by Foster Hill fault (FHF), which has not been seen in outcrop in the Percy qd; the possibility that the member is a volcaniclastic facies of the Perry Mountain has not been ruled out

**Aziscohos Formation (Ordovician, Whiterockian, to Upper Cambrian?)**—Mainly pelitic phyllite and schist that can be considered a pelitic southern facies of lower part of Dead River Formation (O€d); lowest part might be coeval with uppermost, well-bedded part of Hurricane Mountain Formation (€h), but lacks melange characteristic of most of Hurricane Mountain and has more pelitic composition. Undated; age assignment changed from Early Ordovician (Moench and Pankiwskyj, 1988a) to agree with age of Dead River Formation. Estimated maximum thickness about 2,000 m (Green, 1964, p. 16), but lower contact not exposed

O€zu **Upper greenish-gray shale member**—Greenish-gray to silvery-gray pelitic phyllite containing 5 percent or less of light-gray metasiltstone, in laminations and beds rarely as thick as 12 cm. Typically contains scattered thin, semiconcordant lenses of vein quartz of metamorphic origin. Maximum thickness about 900 m; inferred by Green (1964) to grade laterally and downward to lower black shale member (O€zl)

O€zl **Lower black shale member**—Rusty-weathering, dark-gray pelitic phyllite containing abundant pink, manganiferous, garnet-rich laminations (coticule), sparse thin beds of chalky-weathering feldspathic metatuff, abundant metadiabase sills, dikes, and possibly some metabasalt flows. Typically contains scattered thin, semiconcordant lenses of vein quartz of metamorphic origin. Inferred maximum thickness about 1,000 m, but lower contact not exposed

€h **Hurricane Mountain Formation (Cambrian?)**—Exposed from Pierce Pond qd, ME, west to Second Connecticut Lake qd, NH. Named by Boone and others (1989) for typical exposures of formation on upper slopes of Hurricane Mountain, in south-central ninth of Pierce Pond qd, ME. Assigned a Cambrian(?) age on basis of probable Cambrian primitive sponges found in Cupsuptic qd, although an Early Ordovician age is not ruled out. Typically, melange composed of rusty-weathering, dark-gray to black, variously sulfidic to nonsulfidic metasiltstone and subordinate metashale; contains about 25 percent of sliver-shaped to nearly equant clasts, typically 1 mm to 1 cm long, of fine-grained, light- to dark-gray or tan, micaceous quartzite. Thinly lenticular remnants of arenaceous beds common, but well-bedded sequences larger than a single outcrop common only in upper 150 m of formation. Upper part of the formation commonly contains pebbly to bouldery metamudstone or metasiltstone; most clasts are micaceous quartzite, but fragments of granite, mafic and felsic volcanic rocks, and ultramafic rocks occur locally. Locally contains raftlike bodies of quartzite, volcanic rocks, and ultramafic rocks mappable at 1:62,500. Most outcrops display anastomosing scaly cleavage (scales tend to flake from cleavage surfaces), rather than planar slaty cleavage. Probable range in thickness is 900–1,200 m. Contact with underlying Jim Pond Formation (Ꞓj) is generally sheared, and parts of Jim Pond are commonly incorporated within melange. Unit interpreted as accretionary, euxinic trench melange

Ꞓj **Jim Pond Formation, undivided (Cambrian?)**—Shown in parts of Pierce Pond qd, ME. Assigned a Cambrian(?) age on basis of tentative U-Pb zircon isotopic age of about 520 Ma (site M–4), and stratigraphic position below Cambrian(?) Hurricane Mountain Formation (Ꞓh). Weakly metamorphosed volcanic and volcaniclastic rocks commonly divisible into a basalt member, a dacite member, and the predominantly sedimentary Magalloway Member. Maximum total thickness about 1,500 m; contact with underlying gabbro of Boil Mountain Complex (Ꞓb9u) conformable. Where underlying Boil Mountain Complex absent, contact with underlying Chain Lakes massif interpreted to be a tectonic ramp that originated during Penobscottian orogeny

Ꞓjf **Dacite member**—Weakly metamorphosed, thickly layered massive to laminated dacitic tuff and ash-flow deposits, and massive to fragmental sodic quartz latite or sodarhyolite flow rock, volcanic breccia, and reworked volcanics. Metamorphosed fragmental sodarhyolite flow rock tentatively dated at about 520 Ma (site M–4). North of Squirtgun fault (SQF), member contains lenses as thick as 20 m of red, laminated, cherty hematite-magnetite iron-formation. Maximum thickness at least 500 m, but thins to feather edge. Contact with underlying basalt member (Ꞓjb) sharp, but there are alternating sequences of dacite and basalt in which individual flows are about 30 m thick

Ꞓjb **Basalt member**—Pillowed and massive basaltic greenstone and minor weakly metamorphosed basaltic lapillite, breccia, mafic graywacke, metadacite, maroon, ferruginous phyllite, and purple jasper. Northwest of Squirtgun fault (SQF), variably about 150–500 m thick; southeast of fault, more than 1,000 m thick. In northeastern corner of Kennebago Lake qd, constitutes all except uppermost 150 m of Jim Pond Formation, but grades southwestward into epiclastic Magalloway Member (Ꞓjm)

Ꞓjm **Magalloway Member**—Previously mapped as Magalloway Member of Dixville Formation (Green, 1968; Harwood, 1973) in Second Connecticut Lake and Cupsuptic qds, ME; affiliation changed to Jim Pond Formation in this publication.[4] At Thrasher Peaks, Cupsuptic qd, felsic volcanic rocks previously assigned to Magalloway are now assigned to Ironbound Mountain Formation (Dsif). Mainly massively bedded metagraywacke and metagraywacke, locally interstratified with gray, green, and tan pelitic phyllite. Locally contains lenticular bodies of pillowed greenstone assigned to basalt member (Ꞓjb) and locally contains unmapped lenses of felsic metavolcanic rocks. Maximum thickness about 1,500 m; grades laterally into dacitic volcanic and pillow basalt members

Ꞓhj **Hurricane Mountain and Jim Pond Formations, undivided (Cambrian?)**—Melange composed of both formations. Rafts of Jim Pond Formation occur in matrix of euxinic melange characteristic of Hurricane Mountain Formation

Ꞓb **Boil Mountain Complex, undivided (Cambrian?)**—Shown only in sections *A–A'* and *C—C'*. Members described under plutonic and related volcanic rocks

ꞒPc **Rocks of Chain Lakes massif, undivided (Cambrian or Proterozoic)**—Shown only in sections *A–A'*, *B–B'*, and *C–C'*. Incompletely mapped and undated (see sites M–6, M–6A) rock assemblage of controversial origin (Boone and Boudette, 1989; Dunning and Cousineau, 1990; Cousineau, 1991; Trzcienski and others, 1992). Cut by Thrasher Peaks fault (TPF) on northwest, intruded by Ordovician Attean and Skinner plutons on northeast (index 2, 6), and structurally overlain on south by Cambrian(?) Boil Mountain Complex. Surface exposures indicate a minimum thickness of 3 km. Trzcienski and others (1992, p. 529) argued that the Chain Lakes body should not be called a "massif;" term used on this map because the body is strongly foliated only at its margins, as described by Trzcienski and others (1992), and behaved as a large structural buttress during Acadian deformation. Broadly divisible into well-stratified gneiss, granofels, amphibolite, and meta-arkose of the Bag Pond Mountain facies (ЄꝐcb), which is gradationally underlain by massive to poorly stratified granofels-matrix diamictite and polycyclic (multigeneration) metagabbro-epidiorite breccia divided into the McKenney Stream (ЄꝐcm), Coburn Gore (ЄꝐcc), and Sarampus Falls (ЄꝐcs) facies; these facies are underlain by a basal sequence of semipelitic layered gneiss called Twin Bridges facies (ЄꝐct), which is intruded by epidiorite at Holeb (ЄꝐch), probably altered gabbro. Diamictite, predominant in massif, typically contains angular to subrounded clasts, as large as 1.5 m, of vein quartz, mafic and felsic plutonic rocks, volcanic rocks, and previously deformed and metamorphosed sedimentary rocks; clasts supported by matrix of massive, aluminous, quartz-feldspar-mica granofels having a grain size of about 1–2 mm. Rocks of massif interpreted to have been regionally metamorphosed in sillimanite zone, subsequently incompletely retrogressively metamorphosed to greenschist facies

ЄꝐcb **Bag Pond Mountain facies**—Informally named for exposures at southeast end of Bag Pond Mountain; previously mapped as layered granofels at Bag Pond Mountain (Boudette and others, 1984). Well-stratified granofels, quartzo-feldspathic gneiss, laminated amphibolite, and meta-arkose. Locally massively bedded, in part containing sparse lithic and quartz fragments as much as 10 cm across; near base of unit are locally abundant quartz-plagioclase-potassium feldspar leucosomes elongated parallel to layering. Predominant prograde metamorphic assemblage is quartz, plagioclase, potassic feldspar, muscovite. Unit interpreted as shallow marine or coastal plain arkose grading downward into subaqueous bimodal volcanic rocks

ЄꝐcs **Sarampus Falls facies**—Informally named for exposures at roadside park on ME Road 27 at Sarumpus Falls, 15 km northwest of Eustis, ME (park and falls shown on Jim Pond 7 1/2-minute qd). Combines rocks previously mapped as granofels and gneiss at Sarampus Falls, massive granofels at Bug Eye Pond, spotted granofels at Kibby Mountain, and polymictic breccia at Kibby Mountain (Boudette and others, 1984). Most of unit composed of massive to poorly stratified granofels-matrix diamictite characterized by variably abundant clasts of metasedimentary and igneous rocks, polycyclic breccia, and quartz; quartz clasts typically about 5 cm across; others 15–50 cm across. Granofels matrix equigranular, grains 1–2 mm across; composed mainly of quartz, feldspar, and mica; small amounts of cordierite, garnet, and sillimanite occur locally. Near east side of massif, predominant rock is closely packed polycyclic metagabbro-epidiorite breccia; apparently grades westward into granofels-matrix breccia through zones of rheomorphic granofels that locally shows flow structure

ЄꝐcc **Coburn Gore facies**—Informally named for exposures west of Coburn Gore, at international border; previously mapped as gneissic granofels at Coburn Gore (Boudette and others, 1984). Gneissic, granofels-matrix diamictite; compared to Sarumpus Falls facies (ЄꝐcs), has relatively more pelitic (aluminous) matrix and less abundant clasts

ЄꝐcm **McKenney Stream facies**—Informally named for exposures on hills near McKenney Stream, in Attean qd (Albee and Boudette, 1972). Previously mapped as polycyclic breccia at McKenney Pond (Boudette and others, 1984); name changed to avoid confusion with McKenney Ponds Limestone Member of Tarratine Formation (Dmtmp). Chaotic mixture of granofels-matrix diamictite and rheomorphic breccia

ЄꝐch **Epidiorite at Holeb**—Informally named for exposures about 2 km east of Holeb; previously mapped as diorite of Chain Lakes massif (Boudette and others, 1984). Massive, medium- to coarse-grained epidiorite and gabbro principally composed of plagioclase and brown to green amphibole; probably altered gabbro. Intrudes Twin Bridges facies (ЄꝐct)

ЄꝐct **Twin Bridges facies**—Informally named for exposures near two bridges across Spencer Stream; previously mapped as semipelitic gneiss at Twin Bridges (Boudette and others, 1984). Semipelitic layered gneiss typically composed of quartz, plagioclase, potassic feldspar, biotite, and sillimanite. Intruded by epidiorite at Holeb (ЄꝐch)

## Central Maine trough

[Predominantly metasedimentary rocks that accummulated without interruption through Silurian and most of Early Devonian time. Southeast of the Silurian tectonic hinge (fig. 3; STH) the Silurian sequence is as much as 5 km thick, and the basal Silurian beds are conformably underlain by the Ordovician (Cincinnatian) Quimby Formation (Oq), described under the Bronson Hill–Boundary Mountains anticlinorium (fig. 3; BHBMA). Northwest of the hinge this sequence thins greatly and apparently grades to near-shore facies represented by the Clough Quartzite (Sc), The Forks Formation (Stf), and other units that are unconformably underlain by Ordovician and older rocks of the BHBMA. The Silurian sequence is conformably overlain by possibly as much as 5 km of Lower Devonian strata that are coeval facies of the Lower Devonian rocks of the BHBMA to the northwest. Formations of the Central Maine trough (CMT) are conveniently divided into western and eastern sequences, the boundary of which is placed (fig. 3) at the approximate southeastern limit of known strongly calcareous rocks in the upper part of the Smalls Falls Formation (Ssf, Ssfe) and the lower part of the Madrid Formation (Sm, Sme). The eastern sequence is somewhat thinner than the western sequence, and the Silurian part contains generally finer grained clastic sediments and much more abundant metalimestone. No mirror image of the Silurian tectonic hinge is recognized near the southeast side of the CMT. Just southeast of the map area, the Waterville Formation (Sw) is conformably underlain by the Ordovician(?) and Silurian (Llandoverian) Hutchins Corner Formation (Osberg, 1988). The Hutchins Corner is not unlike the Quimby Formation (Oq) of the BHBMA, but, unlike the Quimby, the base of the Hutchins Corner might be a major unconformity above significantly older, previously metamorphosed rocks (Osberg, 1988)]

### *Western sequence*

[See fig. 3 for location of eastern boundary; corresponds to northwestern limit of eastern facies of Madrid and Smalls Falls Formations]

Dl **Littleton Formation, main body (Lower Devonian)**—Mapped in NH and westernmost ME, in areas of sillimanite-zone metamorphism. Mainly gray, massive to cyclically bedded pelitic schist and graded beds of metasiltstone and metasandstone. Broadly equivalent to the Seboomook Group and probably in part coeval with formations of the Moose River Group. In Bethel and adjacent qds, ME, rocks of Carrabassett (Dsc), Hildreths (Dsh), and Mount Blue (Dsm) Formations of Seboomook Group recognized locally within Littleton, but were not mapped separately. Probably at least 2,000 m thick, but upper part eroded. Sedimentary contact with underlying Madrid Formation (Sm) abruptly gradational and conformable. In areas of migmatitic gneiss, lower part of Littleton locally may contain abundant remnants of Madrid Formation

#### Seboomook Group (Lower Devonian)[5, 8]

Dsu **Upper shale and sandstone**—Mapped in Little Bigelow Mountain and Stratton qds, ME, where divisible into upper thickly bedded and lower medium-bedded members (Boone, 1973; not shown separately). Characterized by cyclically interbedded dark-gray slate or schist and graded, lighter gray metasiltstone and metasandstone. About equal amounts of pelitic schist to coarser clastics occur in upper member; pelitic schist predominant in lower member. About 700 m thick, but upper part eroded. Conformably underlain by Hildreths Formation (Dsh), or Carrabassett Formation (Dsc) where Hildreths absent

Dsd **Day Mountain Formation[8]**—Cyclically interbedded thick, graded beds of white- to medium-gray metasandstone and metasiltstone, and dark-gray pelitic schist. Proportions of metasandstone and metasiltstone combined to pelitic schist range from about equal in northwestern exposures to about 4:1 in southeastern exposures. At least 1,000 m thick, but upper part eroded; conformably underlain by Temple Stream Formation (Dst)

Dsdg **Granule conglomerate lenses**—Thick graded beds of coarse-grained metasandstone and granule conglomerate interstratified with typical rocks of the Day Mountain Formation. Mapped in lenses as much as 350 m thick

Dsdl **Impure limestone lenses**—Thinly interbedded, light-gray, arenaceous metalimestone and calcareous metasiltstone, and subordinate dark-gray pelitic schist; rusty-weathering, sulfidic, dark-gray metasandstone locally abundant. Mapped in lenses as much as 250 m thick

Dst **Temple Stream Formation[8]**—Rusty-weathering, dark-gray to black sulfidic schist interbedded with sulfidic, variably calcareous, resistant to punky-weathering metasandstone and metasiltstone; locally contains thin to very thick, graded beds of quartz-rich polymictic metaconglomerate. Metaconglomerate most abundant near upper contact; strongly calcareous metasandstone and metasiltstone most abundant in lower part of formation. Basal several meters has cyclic style of bedding characteristic of underlying Mount Blue Formation (Dsm). About 250 m thick. Conformably underlain by Mount Blue Formation; contact marked by abruptly gradational downward decrease in pyrrhotite and pyrite

Dsm **Mount Blue Formation**[8]—Typically cyclically interbedded dark-gray pelitic schist and lighter gray, graded metasiltstone and metasandstone; locally contains very pelitic sequences of dark-gray, massive schist and arenaceous sequences containing graded and cross-laminated metasandstone beds as much as 1 m thick. Lower part typically rusty weathering, dark gray to black, and sparsely sulfidic. Similar to Carrabassett and Day Mountain Formations (Dsc, Dsd), but contains a larger proportion of arenaceous rocks than Carrabassett and a smaller proportion than Day Mountain. Approximately 500–750 m thick. Conformably underlain by Hildreths Formation (Dsh); contact sharp. In areas of migmatitic gneiss, lower part locally may contain abundant remnants of Hildreths Formation

Dsh **Hildreths Formation**—Thinly bedded calc-silicate rocks, local white marble, thin to 1-m-thick beds of dark-gray volcaniclastic metagraywacke, and black, sulfidic schist; calc-silicate rock and black schist predominant in Stratton and Little Bigelow Mountain qds, ME, but metagraywacke and calc-silicate rocks variably subequal in Rumford and adjacent qds, ME. About 300 m thick in Stratton and Little Bigelow Mountain qds; maximum thickness about 100 m thick farther south. Conformably underlain by Carrabassett Formation (Dsc); contact sharp

Dshe **Euxinic shale member**—Interbedded rusty-weathering, sulfidic-graphitic schist and metasandstone

Dsc **Carrabassett Formation**—Separable in Little Bigelow Mountain qd, ME, and in most areas to the southwest into two regionally extensive members, not shown separately on map: (1) upper member, about 250 m thick, of thinly interbedded metasandstone and gray pelitic schist, in about equal amounts; (2) lower member, about 1,100 m thick, of dark-gray, massive to faintly graded pelitic schist, having local zones of cyclically interbedded pelitic schist and graded metasiltstone and metasandstone. Conformably underlain by Madrid Formation (Sm); contact gradational by interbedding, and thick beds of Madrid-type metasandstone commonly occur as much as 100 m above mapped contact. In areas of migmatitic gneiss, Carrabassett and Madrid Formations not easily separated and some rocks mapped as Carrabassett contain abundant remnants of Madrid Formation

Dscq **Impure quartzite member**—Little Bigelow qd, ME. Lenses of thickly bedded metasandstone and subordinate gray pelitic schist. Thickest metasandstone beds are massive, poorly graded, and locally show evidence of channeling; lower parts of some beds have quartz grains as large as 3 mm. Maximum thickness about 150 m. Interpreted as cross sections of shoestring sands

Dsce **Euxinic shale member**—Rusty-weathering, sulfidic-graphitic pelitic schist and subordinate metasiltstone or metasandstone. Mapped in upper part of Carrabassett south of Blueberry Mountain fault (BMF) in Phillips qd, ME. Maximum thickness about 200 m; lower contact sharp and conformable

DSmm **Mount Blue, Hildreths, and Carrabassett Formations (Lower Devonian) and Madrid Formation (Silurian?), undivided**—Shown in migmatitic gneiss of Bryant Pond qd, ME. Coarsely crystallized sillimanitic two-mica gneiss containing variable amounts of semiconcordant granitic to pegmatitic lenses; bedding typically disrupted; calc-silicate rocks and calcareous biotite granofels of Madrid and Hildreths Formations occur as blocks or lenses in matrix of migmatitic gneiss. Identification of formations difficult

DSlr **Littleton Formation (Lower Devonian), Madrid Formation (Silurian?), and Smalls Falls, Perry Mountain, and Rangeley Formations (Silurian), undivided**—Shown in migmatitic gneiss of Bethel, Gorham, and Mount Washington qds. Similar to gneiss of Bryant Pond qd (DSmm), but rusty-weathering more widespread and pods of granofels and calc-silicate rock more abundant; thought to contain high proportion of rocks derived from Rangeley Formation. Identification of formations difficult

Stf **The Forks Formation (Silurian?; Pridolian? and Ludlovian?)**[9]—Little Bigelow Mountain and Pierce Pond qds, ME. Divisible into upper member of thickly bedded, slightly calcareous, feldspathic metasandstone, about 120 m thick, and lower member of thinly bedded calcareous metasandstone, metasiltstone, impure metalimestone, and thin basal metaconglomerate, about 95 m thick. Age based on conformable position below Carrabassett Formation (Dsc), and correlation with fossil-dated Fitch Formation (Sf). Unconformably underlain by Dead River Formation (O€d)

Sm **Madrid Formation (Silurian?; Pridolian? and Ludlovian?)**—Divisible into upper sandstone member and lower calcareous member, not shown separately. Upper member, about 200 m thick in Phillips qd, composed of thickly to thinly bedded, light-purplish-gray, variably calcareous, feldspathic metasandstone and metasiltstone, and minor to abundant medium-gray pelitic schist. Lower calcareous member, about 90 m thick in Phillips qd, composed of thinly bedded, white, green, light-purplish-gray, and bluish-gray calc-silicate rocks, and weakly calcareous, feldspathic metasandstone and metasiltstone; at Madrid, beds of feldspathic metasandstone as thick as 3 m, locally containing edgewise chip conglomerate, occur near lower contact. Age based on conformable position below Carrabassett Formation (Dsc) and above Smalls Falls Formation (Ssf), and correlation with fossil-dated Fitch Formation (Sf). Total thickness about 300 m in Phillips qd. Conformably underlain by Smalls Falls Formation; contact sharp

Smsf **Madrid Formation (Silurian?) and Smalls Falls Formation (Silurian), undivided**—Shown in Mount Washington qd, NH, where too thin to separate

Ssf **Smalls Falls Formation (Silurian; Ludlovian?)**—Divisible into upper calcareous member and lower black shale and quartzite member. Upper calcareous member, about 150 m thick in Phillips qd, composed of rusty-weathering, pyrrhotite-rich, thinly bedded calcareous metasandstone, metasiltstone, impure metalimestone, and black phyllite; laminations of garnet-rich meta-ironstone occur near upper contact. Lower black shale and quartzite member, about 600 m thick in Rangeley and Phillips qds, composed of rusty-weathering, pyrrhotite-rich, thinly interbedded quartzite and black, graphitic schist; beds of quartz-granule metaconglomerate, 50 cm to 3 m thick, common north of Madrid village. Age based on correlation with fossil-dated rocks of formation in eastern sequence. Maximum total thickness of 750 m in Phillips, Rangeley, and Rumford qds, ME; thins abruptly northward and gradually southeastward. Conformably underlain by Perry Mountain Formation (Sp); contact variably sharp to gradational through several meters

Sp **Perry Mountain Formation (Silurian; Ludlovian? and Wenlockian?)**—Sharply interbedded white quartzite and light-gray, muscovite-rich pelitic schist or pale-green slate. Quartzite beds commonly cross- or convolute-laminated, abruptly graded at upper contacts, and exhibit partial to complete bouma sequences; commonly contain garnet-rich lenses and laminations (coticule) near lower contacts. Unit includes sparse trachytic metavolcanic rocks in Kennebago Lake qd and coarse-grained, volcaniclastic metasandstone in Kingfield qd. About 600 m thick in Rangeley qd, ME, but less than 100 m thick where it overlies Silurian Sangerville Formation (Ss) in eastern sequence. Age based on conformable position below Smalls Falls Formation (Ssf) and above member C of Rangeley Formation (Src); lower contact gradational by interbedding through several tens of meters

Spv **Volcanic-bearing facies**—Kennebago Lake qd, at high level on East Kennebago Mountain. Weakly metamorphosed felsic volcanic rocks interstratified with characteritic metasedimentary rocks of formation. Metavolcanic rock occurs in layers as much as 7 m thick; varies from light-brown, medium- to coarse-grained, plagioclase-porphyritic quartz latite porphyry to mottled-gray, flow-banded aphanite. Correlated with mixed sedimentary and volcanic facies of Perry Mountain Formation in Piermont sequence

Sc **Clough Quartzite (Silurian; upper Llandoverian)**—Shown near northwest end of Kennebago Lake, Kennebago Lake qd, ME, where previously mapped as part of member C of Rangeley Formation (Boudette, 1979; Moench and Pankiwskyj, 1988a); after maps by Moench and Pankiwskyj and Boudette were prepared for publication, assigned to the Clough Quartzite by Moench and Boudette (1987) on basis of similarity in lithology and age to type Clough Quartzite of western NH. Exposed at same stratigraphic level as the fossiliferous, upper Llandoverian rocks of member C of Rangeley Formation (Srcl) to southeast in Kennebago Lake qd. Composed of light-gray, massive, lenticularly bedded orthoquartzite and quartz conglomerate. Maximum thickness about 100 m. Probably disconformably underlain by shale and sandstone submember (Srb) and by quartz-rich polymictic conglomerate lens (Srbc), both of member B of Rangeley Formation. Interpreted as shoreline or near-shore facies of lower part of member C of Rangeley Formation (Srcl, Srcq)

Sr **Rangeley Formation (Silurian; Llandoverian)**—Mapped undivided locally in areas of high-grade metamorphism; mainly interbedded rusty-weathering, dark-gray pelitic schist and rusty-weathering feldspathic quartzite; quartzite beds commonly contain calc-silicate pods and lenses, which in gneissic areas are commonly isolated in micaceous gneiss. In Franconia qd, NH, divided into upper and lower members having characteristics of the Rangeley farther south in NH. In Rangeley, Kennebago Lake, and Old Speck Mountain qds, ME, divided into three members (A, B, C; ascending order), each of which is divided into two or more submembers, lenses, or facies (Moench and Boudette, 1987). Age based on late Llandoverian fossils in member C of formation in Kennebago lake qd; underlying members B and A considered earlier Llandoverian in age. Maximum total thickness in central part of Rangeley qd about 3,000 m; thins gradually southward to about 2,500 m at the southern edge of same qd, and thins abruptly northward to about 500 m in the central part of Kennebago Lake qd; there composed mainly of member C. Conformably underlain by Greenvale Cove Formation (Sg); contact abruptly gradational. Lower contact of member B (Srbg) just north of Kennebago Lake fault (KLF) considered an unconformity above Dead River Formation (O€d)

Src **Member C, undivided**—Mapped undivided locally in Rangeley, Rumford, Old Speck Mountain qds, ME, and Gorham qd, NH. Rocks assigned to lower member of part C (member C of this map) by Moench and Pankiwskyj (1988a) have been reassigned to the Clough Quartzite in the area near the north end of Kennebago Lake, Kennebago Lake qd, ME. Divided into an upper gray shale and sandstone submember and two lower units that contain quartzite and quartz conglomerate. Total thickness about 500 m

Srcu **Upper gray shale and sandstone submember**—Rusty-weathering, thickly to thinly interbedded, dark-gray pelitic schist, metasandstone, and local quartz grit; bedding features similar to nonconglomeratic part of member B (Srb), but quartz more abundant in metasandstone of member C (Src). About 450 m thick in Kennebago Lake qd, ME; thins southward by loss of metasandstone to about 150 m at south side of Rangeley qd

Srcl **Impure limestone and quartz conglomerate lenses (upper Llandoverian)**—Dated by fossils found in quartz-granule conglomerate near south end of Kennebago Lake, Kennebago Lake qd, ME, and in calc-silicate rock about 7 km west of Stratton, in Stratton qd, ME. Composed of laminated calc-silicate rocks underlain by interbedded quartz-granule to quartz-pebble metaconglomerate, metasandstone, and gray pelitic hornfels. Total thickness about 60 m. Contact with underlying metashale of member B (Srb) sharp and conformable; inferred to change northward to disconformity and unconformity

Srcq **Quartz conglomerate, sandstone, and gray shale submember**—Interbedded light-gray quartz-cobble to quartz-granule conglomerate; rusty-weathering feldspathic quartzite; and rusty-weathering gray pelitic schist. Conglomerate is typically closely packed, commonly graded, and locally shows channels; clasts are vein quartz, quartzite, and rip-up clots of pelitic schist; sparse felsite cobbles or pebbles found locally; local schist-matrix conglomerate, interpreted as conglomeratic mudflow deposits. About 200 m thick in central part of Rangeley qd; becomes thinner and finer grained southward; inferred to change northward into impure limestone and quartz conglomerate (Srcl) exposed in Kennebago Lake qd. Lower contact conformable; placed at the base of first bed of quartz conglomerate above gray shale and sandstone of member B (Srb)

**Member B**—Divided into gray shale and sandstone submember (Srb) and quartz-rich polymictic conglomerate lenses (Srbc). Maximum total thickness about 1,200 m in central part of Rangeley qd; thins southward by loss of conglomerate and sandstone to about 700 m at south edge of Rangeley qd, and thins northward to a few tens of meters of rusty-weathering phyllite just north of Kennebago Lake fault (KLF), in Kennebago Lake qd. Contact with underlying polymictic conglomerate and sandstone of member A (Srac, Sras) in Rangeley qd sharp and conformable; contact of phyllite of member with underlying Dead River Formation (O€d) north of Kennebago Lake fault interpreted as unconformity

Srb **Gray shale and sandstone submember**—Rusty-weathering, dark-gray pelitic schist containing subequal to greatly subordinate amounts of feldspathic quartzite; inclusions in Redington pluton (index 25) also contain sparse conglomerate. Quartzite beds a few millimeters to 1 m thick; planar, but single outcrops commonly contain thick and thin beds; typically massive to parallel-laminated, characteristic of bouma A and B intervals, abruptly graded near upper contacts. Metasandstone contains more quartz than metasandstone of member A (Sras) but less quartz than metasandstone of member C (Src). Metasandstone dikes, flute- and load-casts, and slump folds are locally conspicuous

Srbc **Quartz-rich polymictic conglomerate lenses**—Irregularly interstratified quartz-rich polymictic conglomerate, rusty-weathering, dark-gray pelitic schist, and feldspathic metasandstone; common slump folds and conspicuous schist-matrix conglomerate, interpreted as conglomeratic mudflow deposits. Conglomerate contains fewer quartz and quartzite clasts than quartz conglomerate of member C (Srcq) and more quartz and quartzite clasts than polymictic conglomerate of member A (Srac); clasts are vein quartz, quartzite, and various other metasedimentary, metavolcanic, and plutonic rocks. Two principal layers mapped in central part of Rangeley qd; aggregate maximum thickness of 300 m. Body in southeast corner of Cupsuptic qd, ME, nearly 300 m thick, interpreted as deep channel fill; lower part contains granite boulders as much as 60 cm across

**Member A**—Divided into polymictic conglomerate facies (Srac), massive sandstone facies (Sras), and gray shale and massive sandstone facies (Sra) representing an upward-coarsening, southward-fining subaqueous fanglomerate. Maximum thickness of conglomerate-sandstone body in central part of Rangeley qd about 1,200 m; thins gradually southward partly by loss of conglomerate and sandstone; abruptly wedges out northward. Contact of conglomerate with underlying Greenvale Cove Formation (Sg) in Kennebago Lake qd sharp and conformable; contact of massive sandstone and interbedded gray shale and massive sandstone in Rangeley qd with underlying Greenvale Cove is abruptly gradational

Srac **Polymictic conglomerate facies**—Massively bedded boulder to pebble conglomerate and massive feldspathic metasandstone. Thin slice along Mahoosuc fault (MF) in Old Speck Mountain qd compositionally similar to same facies in Rangeley qd, but more deformed; composed of extremely rodded pebbles to small boulders, variably rounded to extremely flattened normal to rodding; rodded clasts plunge consistently 80° NE. in plane of foliation. Clasts are granite, metasedimentary and metavolcanic rocks and vein quartz; supported by matrix of quartz-feldspar granofels. In Rangeley qd, facies characterized by individual conglomeratic beds as thick as 10 m; commonly lenticular and locally channel deeply into underlying beds; inverse-to-normal grading and outsized cobbles or pebbles in upper metasandstone of thick graded beds are common. Clasts as large as small boulders near Rangeley Lake, slightly elongate along steep northeast plunges. Clasts are various plutonic, metavolcanic, quartzite, and other metasedimentary rocks and vein quartz; also contains granite cobbles containing phenocrysts of blue quartz probably derived from Silurian or Ordovician quartz porphyry (SOh2f) exposed farther north in and near Attean qd, ME. Lower and lateral contacts with massive sandstone facies (Sras) are gradational

Sras **Massive sandstone facies**—Massively bedded, coarse-grained, feldspathic metasandstone. Individual beds, as thick as 10 m, are poorly graded, commonly show parallel lamination and rarely show large-scale convolute laminations near upper contacts. Lower and lateral contacts with gray shale and massive sandstone facies (Sram) are gradational; contact with underlying Greenvale Cove Formation (Sg), where gray shale and massive sandstone facies (Sra) is absent, is abruptly gradational

Sra **Gray shale and massive sandstone facies**—Rusty-weathering, thickly interbedded, dark-gray pelitic schist and massive, feldspathic metasandstone; abundance of schist equal to, or greater than, abundance of metasandstone; metasandstone beds commonly 1 m thick, massive, abruptly graded at upper contacts. Conformably underlain by Greenvale Cove Formation (Sg); contact abruptly gradational

Srba **Members B and A, undivided**—Shown near south end of Kennebago Lake, Kennebago Lake qd, ME

Sru **Upper member near North Woodstock**—Franconia qd, NH. Rusty-weathering, thickly stratified, dark-gray pelitic schist and quartz-feldspar granofels containing scattered pods of calc-silicate rock. Considered approximately equivalent to member C of Rangeley qd. Thickness uncertain; probably several hundred meters

Srl **Lower member near North Woodstock**—Franconia qd, NH. Rusty-weathering, thinly stratified, dark-gray pelitic schist and quartz-feldspar granofels. Considered approximately equivalent to member B of Rangeley qd. Probably at least 1 km thick

Spr **Perry Mountain and Rangeley Formations, undivided (Silurian)**—Shown in Old Speck Mountain qd, ME

Sg **Greenvale Cove Formation (Silurian?; lower Llandoverian?)**—Typically sharply interlaminated (1 cm), light-purplish-gray, weakly calcareous, feldspathic metasandstone and metasiltstone, medium-gray slate, and minor purplish-gray to white calc-silicate rock. At Rangeley Lake, ME, uppermost 30 m contains 1-m-thick beds of coarse-grained, feldspathic metasandstone similar to overlying massive sandstone of Rangeley Formation (Sras). Originally considered Late Ordovician(?) in age (Moench, 1969). Moench and Pankiwskyj (1988a) assigned an early Llandoverian(?) age to Greenvale Cove, on basis of long-distance correlation with fossiliferous Aroostook River Formation (Roy and Mencher,1976) of northern Maine; an Ordovician (Cincinnatian) age is not ruled out but is unlikely because basal volcanic member of underlying Quimby Formation (Oqv) has yielded an age of 444 Ma (site M–10) with a margin of error that overlaps the Ordovician-Silurian time boundary. About 200 m thick. Conformably underlain by Quimby Formation (Oq); contact sharp. Interpreted as fine-grained detritus derived from emerging western source area

*Eastern sequence*

[See fig. 3 for location of western boundary; corresponds to northwestern limit of eastern facies of Madrid and Smalls Falls Formations]

Dsc **Carrabassett Formation of Seboomook Group (Lower Devonian)**—Kingfield qd, ME. Typically massive, dark-gray slate or schist; commonly cyclically interbedded with smaller amounts of lighter gray graded metasiltstone and fine-grained metasandstone. Conformably underlain by eastern facies of Madrid Formation (Sme); contact gradational by interbedding

Sme **Eastern facies of Madrid Formation (Silurian?; Pridolian? and Ludlovian?)**—Similar to upper sandstone member of type Madrid of Phillips qd, ME; lacks the thinly bedded, lower calcareous member. Typically thickly bedded, light-purplish-gray, massive, well-sorted, weakly calcareous metasandstone; beds average about 50 cm thick and are separated by thin partings and beds of gray slate or schist; calc-silicate beds and pods are common. Thinly (1–3 cm) interbedded cross-laminated metasandstone and pelitic slate or schist occur at several levels within formation. More than 750 m thick in Kingfield qd and farther east in ME. Conformably underlain by eastern facies of Smalls Falls Formation (Ssfe); contact abruptly gradational

Ssfe **Eastern facies of Smalls Falls Formation (Silurian; Ludlovian)**—Dated by early Ludlovian graptolites found east of map area (Pankiwskyj and others, 1976, locality F9D4; Moench and Pankiwskyj, 1988a). Similar to lower black shale and quartzite member of type Smalls Falls of Rangeley and Phillips qds, ME, though typically somewhat less sulfidic and lacks thinly bedded calcareous upper member of type Smalls Falls. Composed of sulfidic-graphitic phyllite and subordinate metasandstone, quartz-rich granule conglomerate, and thinly laminated, fissile metasiltstone. Maximum thickness about 300 m. Conformably underlain by Perry Mountain Formation (Sp); contact abruptly gradational

Sp **Perry Mountain Formation (Silurian; Ludlovian? and Wenlockian?)**—East side of Livermore qd. Sharply interbedded feldspathic metasandstone and greenish-gray pelitic phyllite or slate, having sedimentary features identical to those of Perry Mountain of western sequence. Age assignment based on conformable position below Smalls Falls Formation (Ssfe) and above Sangerville Formation (Ss). Less than 100 m thick; conformably underlain by Sangerville Formation

**Sangerville Formation (Silurian; Wenlockian and Llandoverian?)**—Dated by graptolites found east of map area (Pankiwskyj and others, 1976; Moench and Pankiwskyj, 1988a); assigned a Wenlockian age by Osberg (1988, p. 55), but Llandoverian age not ruled out by paleontologic data. Divided into principal sandstone and shale facies (Ss) and several members and lenses. Sedimentary styles of metasandstone beds resemble styles of sandstone beds of members B and C of Rangeley Formation (Srb, Src); interpreted to grade laterally westward into Rangeley Formation (Sr) and into lower part of Perry Mountain Formation (Sp) of western sequence. Possibly as much as 2,000 m thick. Intraformational contacts of facies, members, and lenses are conformable. Conformably underlain by Waterville Formation (Sw); contact sharp

Ss **Principal sandstone and shale facies**—Widely exposed southeast of possible Rowell Mountain fault (RMF?). Thinly to thickly interbedded (5 cm to 1 m) lithic metasandstone and generally subordinate gray to greenish-gray, laminated or massive slate or schist. Metasandstone beds are poorly to moderately sorted and contain wide variety of lithic fragments bound by argillaceous or calcareous matrix; commonly exhibit cross and convolute laminations, sedimentary breccia, and slump folds. Proportions of metasandstone to metashale range from 10:1 to 1:1

Sst **Thorncrag Hill Member of Hussey (1983)**—Named as member of Sangerville Formation (Hussey, 1983) after exposures on Thorncrag Hill, Lewiston qd, ME. Dark-gray, micaceous, migmatitic pelitic gneiss and scattered beds of calc-silicate rocks. Probably about 250 m thick

Ssl **Unnamed limestone member**—Calcareous rocks similar to Patch Mountain Limestone Member (Ssp) but apparently occurring at higher stratigraphic level

Sstp **Taylor Pond Member of Hussey (1983)**—Named as member of Sangerville Formation (Hussey, 1983) after exposures at Taylor Pond, Poland qd. Dark-gray, feldspathic biotite- and hornblende-biotite granofels, thinly bedded calc-silicate rocks, and sparse garnet-rich laminations (coticule). Probably about 500 m thick

Sse **Euxinic shale lenses**—Rusty-weathering, sulfidic-graphitic pelitic schist or phyllite. Maximum thickness probably about 250 m

Ssc **Conglomerate member**—Exposed near east edge of Kingfield and Farmington qds, ME. Lenses, as much as 250 m thick, of thickly bedded, polymictic conglomerate, conglomeratic lithic metasandstone, and subordinate slate or pelitic schist. Conglomeratic beds may be massive or conspicuously graded. Clasts range from 2 mm to 5 cm in long dimension; composed of quartz, feldspar, quartzite, chert, felsic to mafic metavolcanic rocks, slate, and hypabyssal and plutonic intrusive rocks

Ssp **Patch Mountain Limestone Member**—At high metamorphic grade, in Bryant Pond and Buckfield qds, ME, composed of thinly interbedded impure marble, coarsely crystallized calc-silicate rocks, biotite-quartz-plagioclase granofels, and minor pelitic schist. At lower metamorphic grade to east, composed of thinly interbedded gray, micritic metalimestone, limy metasandstone, metasiltstone, and slate or pelitic schist; contains features common to turbidites. Originally defined as Patch Mountain Formation (Guidotti, 1965); subsequently revised as Patch Mountain Member of Sangerville Formation (Moench and Pankiwskyj, 1988a); here called Patch Mountain Limestone Member, to emphasize its calcareous composition. Maximum thickness about 600 m; contact with underlying principal sandstone and shale facies (Ss) or with underlying Waterville Formation (Sw), where principal sandstone and shale facies is absent, tentatively considered to be conformable

Sw **Waterville Formation (Silurian; Wenlockian and Llandoverian)**—Queried where identification conjectural. Dated by late Llandoverian and Wenlockian graptolites found east of map area (Osberg, 1988, p. 55, and references therein). In Lewiston qd, composed of thinly bedded, gray to greenish-gray slate or pelitic schist, smaller amounts of wacke, and sparse calc-silicate rocks. Where queried in Bryant Pond, Buckfield, Dixfield, and Farmington qds, previously mapped as Anasagunticook Member of Sangerville Formation (Moench and Pankiwskyj, 1988a; name not used in this publication), interpreted by Moench and Pankiwskyj as fine-grained facies of main body of Sangerville, and thought by them to conformably overlie Patch Mountain Limestone Member of Sangerville. Former Anasagunticook Member correlated with

Waterville Formation by Osberg (1988, table 1 and fig. 3) on basis of lithologic similarity; here tentatively reassigned to Waterville Formation to simplify nomenclature. Where previously mapped as Anasagunticook Member, typically composed of thinly interbedded fine-grained feldspathic metasandstone and pelitic schist; also locally contains thick beds of coarse-grained metasandstone, metasandstone beds commonly graded, characteristically conspicuously cross- and convolute-laminated. Estimated thickness 500–600 m east of map area (Osberg, 1988, p. 57). Conformably underlain by Ordovician(?) (late Cincinnatian?) and Silurian(?) (Llandoverian?) Hutchins Corner Formation (Osberg, 1988, p. 56, 57), exposed to east of map area. Interpreted to grade westward into lower part of Rangeley Formation (Sr) and Greenvale Cove Formation (Sg)

Swl **Limestone member**—Queried where assignment to Waterville Formation is conjectural. At high metamorphic grade, in Bryant Pond and Buckfield qds, ME, composed of coarsely crystallized, thinly layered calc-silicate rocks. At lower metamorphic grade in Farmington, Livermore, and Lewiston qds, composed of micritic metalimestone, calcareous metasiltstone, and pelitic slate or schist. Most rocks were previously mapped as Berry Ledge Formation in Bryant Pond qd (Guidotti, 1965); however, in order to keep nomenclature as simple as possible, the name Berry Ledge is not used here. Thickness probably ranges between 100 m and 300 m

Swe **Euxinic shale lenses**—Thinly lenticular bodies of rusty-weathering, black, sulfidic slate or phyllite

## STRATIGRAPHIC NOTES

**Note 1.**—McHone and Butler (1984, p. 761) noted that Cretaceous as well as Jurassic isotopic ages have been obtained for the various bodies of pink biotite granite in central New England that have been mapped in the past as Conway Granite. The Conway is a distinctive granite of considerable economic interest, but the fact that different bodies previously mapped as Conway have different ages indicates that it is not a time-stratigraphic unit, except in its type area, near Conway, New Hampshire, in the White Mountain batholith (index 81). On this map, therefore, the formal name "Conway Granite" is applied only to exposures of characteristic pink mesoperthite-biotite granite of the pluton centering at North Conway, in the White Mountain batholith, which has yielded a K-Ar age of 183±5 Ma (site J–9; see Foland and Faul, 1977, app. 2, for a listing of older data). Similar granite that occurs elsewhere within and outside the batholith is here informally called "Conway-type granite." All of the major bodies of Conway-type granite in the map area have yielded Jurassic isotopic ages that range from 155±4 Ma to 194±4 Ma (sites J–2, J–3, J–4, J–6, J–7, J–8, J–10, J–11).

**Note 2.**—Billings (1937, p. 501; 1956, p. 48) named the Oliverian magma series to designate foliated intrusive granitic rocks exposed in the cores of several gneiss domes that compose the Bronson Hill anticline (Billings, 1956, p. 109, 122), or anticlinorium (BHA), in western and northern New Hampshire. The term "Oliverian" is confusing, however, because it has been applied variously to the plutonic rocks that form the cores of the gneiss domes (Billings, 1956), to the gneissic texture of the core rocks (Zartman and Leo, 1985), and to the domes themselves (Chapman, 1939; Naylor, 1969), which include the core plutons and the domed country rocks. There is much debate, furthermore, about the intrusive, as opposed to the volcanic, origin of the core rocks of some domes south of the area of this map (for example, Naylor, 1969).

In this publication, the term "Oliverian Plutonic Suite" is applied to the weakly to strongly foliated (locally gneissic) intrusive rocks of the plutons that make up the cores of the domes exposed along or near the axial trace of the Bronson Hill anticlinorium. This usage accords with Billings' (1956) definition, which is modified to conform with the current stratigraphic code. Rocks of the Oliverian Plutonic Suite are shown as discrete named plutons on this map; each pluton is more or less centrally located in a dome, and carries the currently accepted name of that dome. For example, the Owls Head pluton of biotite granite (index 92; Oo1b) forms the intrusive core of the Owls Head dome; the Jefferson batholith, composed of several rock types of the Oliverian Plutonic Suite, is the intrusive core of the Jefferson dome.

Isotopic age data provided with this map indicate that most plutons of the Oliverian Plutonic Suite are Ordovician in age, mainly Mohawkian or Cincinnatian (sites O–2, O–8, O–10, O–12). However, zircons from ductile mylonite of the slice of the Moody Ledge pluton (index 89) have been dated at 435±3 Ma (site S–3); because it is uncertain whether this determination represents the time of crystallization or mylonitization, this body and the main body (index 88) with which it is correlated must be considered either Ordovician or Silurian in age. Additionally, syenite to quartz syenite of the

Jefferson batholith (index 63; SOo4–7h) has been dated at 441±5 Ma, which is the approximate age of the Ordovician-Silurian boundary, according to Tucker and others (1990); this body is therefore considered to be either latest Ordovician or earliest Silurian in age, which age is here assigned as well to other rocks of the Jefferson batholith (units SOo1h, SOo4Ch, SOo4bx) that appear to be related to the syenite to quartz syenite.

In summary, because most rocks of the Oliverian Plutonic Suite are certainly Ordovician (Mohawkian or Cincinnatian), but some are either latest Ordvocian or earliest Silurian, the suite as a whole is here assigned an Ordovician and Silurian(?) age.

**Note 3.**—The Chickwolnepy intrusions are a north-trending body, about 10 km long and 2–4 km wide, of metamorphosed gabbro and sheeted diabase (Oc9B) and tonalite (Oc3Ah, Oc3Ahx) exposed on Chickwolnepy Mountain and extending across Chickwolnepy Stream, in the central part of the Milan quadrangle, New Hampshire (index 39). The Chickwolnepy intrusions also tentatively include a lenticular body of quartz-porphyritic tonalite (Oc3Ahx) northwest of the main body and, tentatively, several nearby isolated metadiabase and metagabbro dikes. These intrusions are informally named in order to highlight their unusual nature and tectonic importance as an inferred center of crustal spreading and subvolcanic plutonism related to the Ammonoosuc Volcanics.

The principal rock varieties of the Chickwolnepy intrusions can be seen at the following locations in the New Hampshire part of the Milan quadrangle, from north to south (see 15-minute quadrangle map): (1) top of Roundtop Mountain and along Bog Brook, at elevations between 1,360 and 1,390 ft, exposing north- to northwest-trending sheeted metadiabase dikes (Oc9B) containing sparse aplitic trondhjemite dikelets; (2) along the ridge that forms the saddle between Cambridge Black and Little Cambridge Mountains at the east side of the saddle, exposing metadiabase and fine-grained metagabbro (Oc9B), locally containing inclusions and septa of Dead River Formation (O€d) (at the west side of the saddle is foliated porphyritic metatonalite (Oc3Ahx), dated at site O–7); (3) east end of Little Cambridge Mountain, exposing coarse- to fine-grained, foliated metagabbro (Oc9B) that contains irregular segregations of metatonalite and aplitic metatrondhjemite, which also forms the matrix of autobreccia; (4) Bald Mountain, especially the steep south and southwest slopes and the summit, exposing metatonalite (Oc3Ah) at low elevations on the southwest side, mixed metatonalite and metagabbro (Oc9B) at middle elevations (locally sheared and altered), foliated metagabbro at the summit, and altered metagabbro and metatonalite high on the north slope; (5) length of Chickwolnepy Mountain, exposing mainly sheeted metadiabase dikes (Oc9B) that trend north to northwest.

Bald Mountain (elevation 2,376 ft) is the most prominent peak within the intrusions and appears to represent the magmatic center of the intrusions.

All of the rocks of the Chickwolnepy intrusions have been metamorphosed along with the country rocks and deformed by metamorphic foliation of Devonian age that is approximately concentric to the Jefferson batholith and the Success lobe of the batholith (index 63, 64). The Chickwolnepy is intruded by granite (Oh1b) of the Cambridge Black pluton of the Highlandcroft Plutonic Suite (index 38), which also is crossed by the same foliation.

The metamorphosed gabbro and diabase are amphibolite composed of blue-green hornblende, calcic plagioclase, minor quartz, and, locally, scattered garnet. Chemically, the rocks are calcic gabbros having exceptionally low titanium and alkali contents (R.H. Moench, unpub. data, 1991). The metatonalite contains abundant quartz and plagioclase, lesser amounts of hornblende, and sparse biotite. Two of the mapped bodies contain rounded quartz phenocrysts as much as 1 cm across. Like the metagabbro and metadiabase, alkali contents are exceptionally low, even for tonalite (R.H. Moench, unpub. data, 1984). Although this might be explained by loss of alkalis during metamorphism, analyses of metabasalt from nearby flows in the Ammonoosuc Volcanics (Oab) indicate tholeiitic compositions that are not similarly depleted in alkali elements.

On the basis of a U-Pb zircon age of 467±3 Ma age for tonalite (site O–7) of the intrusions, the Chickwolnepy intrusions are here assigned an Ordovician (late Whiterockian) age. The Chickwolnepy intrusions cut the Dead River Formation (O€d) and the basaltic facies in the lower part of the Ammonoosuc Volcanics (Oab). The intrusions are interpreted to be subvolcanic sources for some of the oldest rocks of the Ammonoosuc Volcanics. Petrochemical studies are needed, however, to determine if the mafic and felsic rocks of the Chickwolnepy intrusions and the Ammonoosuc Volcanics are comagmatic.

**Note 4.**—This note describes the major stratigraphic revisions that have resulted from mapping done since about 1970 and since the recognition of the Piermont allochthon in 1985 (Moench and others, 1987; Moench, 1992, and references therein), which is here shown as the Piermont-Frontenac allochthon (fig. 3) on the basis of fieldwork done since the 1992 paper was prepared. Briefly, rocks that were previously mapped as the Ordovician Albee Formation (Billings, 1935, 1937, 1956), the Middle Ordovician Dixville Formation (Green, 1964, 1968; Green and Guidotti, 1968), and the Lower Devonian Kidderville Formation (Hatch, 1963) are reassigned to other units; accordingly, these names are not used in this publication.

*Albee Formation*

Rocks of the Albee Formation of Billings (1956) exposed in New Hampshire outside the Piermont-Frontenac allochthon are here reassigned to the Upper Cambrian(?) and Ordovician (lower part) Dead River Formation (OЄd) of Maine (Boone, 1973; Osberg and others, 1985). The remaining parts of the Albee exposed within the allochthon between the area of Piermont, New Hampshire, and Magalloway Mountain, New Hampshire, (fig. 3) are reassigned to the Quimby and Greenvale Cove Formations (described by Moench, 1990, south of the map area) and to the Rangeley, Perry Mountain, Smalls Falls and Madrid Formations, all of the Piermont sequence, and, in the Guildhall quadrangle, Vermont, to the Frontenac Formation; these units collectively range in age from latest Ordovician to latest Silurian(?). The type localities of the six formations of the Piermont sequence are in Maine (Osberg and others, 1968; Moench and Boudette, 1970, 1987; Moench and Pankiwskyj, 1988a). Also within the area of the allochthon, but considered parallochthonous, are small bodies assigned to the Lower Devonian Ironbound Mountain Formation (see note 6).

Billings (1935, p. 9) named the Albee Formation for "a group of slates and quartzites typically exposed on Gardner Mountain," in the area of low-grade metamorphic rocks that lies between the Monroe (MNF) and Ammonoosuc (AF) faults. The type area is a 10-km length of Gardner Mountain extending southwest from Albee Hill (Littleton quadrangle), from which the name was obtained. Billings also mapped the Albee southeast of the Ammonoosuc fault, and he and his associates subsequently mapped the Albee from the Piermont area, New Hampshire, northeastward into Maine (Billings, 1956; Green and Guidotti, 1968; Harwood, 1973). According to published descriptions, the Albee is composed mainly of schist and quartzite; metavolcanic rocks are not reported as a major constituent. Billings assigned an Ordovician age to the Albee Formation, and an important component of his definition is his inference that the Albee conformably underlies the Ordovician (Whiterockian and Mohawkian) Ammonoosuc Volcanics.

Mapping done from 1983 to 1992 indicated that rocks previously mapped as the Albee Formation throughout northern New Hampshire (Billings, 1956) and northeastern Vermont (Doll and others, 1961) are divisible into two rock assemblages. One assemblage includes rocks of the strike belt that extends across the type area of the Albee Formation, where the Albee was found to contain metamorphosed volcanic and volcaniclastic rocks as well as gray, black, and green pelitic schist and variably feldspathic quartzite, and minor amounts of weakly calcareous rocks. Although Moench (1984) tentatively correlated this volcanic-bearing rock assemblage with the Cambrian(?) Jim Pond and Hurricane Mountain Formations, felsic metavolcanic and hypabyssal intrusive rocks of the assemblage subsequently yielded Silurian U-Pb zircon ages (sites M–1 to M–3, M–7, M–8). The whole assemblage was found, moreover, to be divisible into the six Ordovician, Silurian and Silurian(?) formations of the Piermont sequence that are listed in the first paragraph of this discussion. Additionally, the inconspicuous but major Foster Hill fault (FHF) was found to separate this assemblage of formations, all considered allochthonous, from the autochthonous sequence that contains the Ammonoosuc Volcanics. It was found, therefore, that the type Albee does not lie stratigraphically below the type Ammonoosuc and that all of the rocks exposed within the type area of the Albee can be assigned conclusively to other named younger formations.

The other assemblage, composed of interbedded feldspathic quartzite and metashale, actually lies below the Ammonoosuc Volcanics and Partridge Formation and, therefore, closely conforms to the original definition of the Albee Formation (Billings, 1935, p. 9). Such rocks are not present in the type area of the Albee. These rocks are widely exposed astride the New Hampshire–Maine border and are coextensive with, and identical to, the Upper Cambrian(?) and Ordovician (Ibexian and Whiterockian) Dead River Formation (OЄd) of Osberg and others (1985), who reassigned rocks that were originally mapped as Albee in westernmost Maine (Green and Guidotti, 1968; Harwood, 1973) to the Dead River. On the basis of the precedence set by Osberg and others (1985), and because the type area of the Albee

Formation is no longer viable, the name "Dead River Formation" is here applied to rocks of the quartzite-metashale assemblage in New Hampshire that are known to lie below the Ammonoosuc Volcanics or the Partridge Formation.

*Dixville Formation*

All of the rocks previously mapped by Hatch (1963), Green (1964, 1968), Green and Guidotti (1968), and Harwood (1973) as the Dixville Formation and its members in northern New Hampshire and adjacent Maine are here reassigned to one or more different units.

Green (1964, p. 23) named the Dixville Formation for rusty-weathering, interbedded dark-gray to black schist and quartzite, basaltic amphibolite, and minor felsic metavolcanic rocks exposed in the township of Dixville, New Hampshire, in the Errol and Dixville qds. Although he did not describe a specific type locality or type area, he cited (p. 23) road cuts along New Hampshire Route 26 in the vicinity of Dixville Notch, Dixville Township, and in Millsfield Township. Green (1964) named three members (p. 24–32), in ascending order: (1) the Dixie Brook Member, after exposures of interbedded rusty-weathering, pyrrhotite-bearing quartzite and gray to black graphitic schist in Dixie Brook, Dixville Township; (2) the Clear Stream Member, after exposures of basaltic amphibolite, subordinate felsic to intermediate metavolcanic rocks, and scattered thin manganiferous beds along Clear Stream, Millsfield Township; (3) the Rice Mountain Member, after exposures of interbedded gray to black sulfidic schist and feldspathic quartzite on Rice Mountain, Dixville Township. Green (1964, p. 61–62) and Hatch (1963, p. 18) correlated the Dixie Brook and Rice Mountain Members with the Partridge Formation, and they correlated the metavolcanic Clear Stream Member with the Ammonoosuc Volcanics of the Littleton-Moosilauke area (Billings, 1935). These correlations gained support when Green and Guidotti (1968, figs. 19–2, 19–3) and Harwood (1973) assigned graptolite-bearing Ordovician black slate (early Mohawkian) and associated basaltic greenstone of the Cupsuptic and Oquossoc quadrangles, Maine, to the Dixville Formation.

Green (1964) demonstrated that sulfidic black schist and quartzite of his Dixie Brook Member conformably overlies nonsulfidic light-gray schist and quartzite that he assigned to the Albee Formation. Graded beds found at the contact support this stratigraphic order. During the post-1978 mapping it was recognized, however, that this sequence is remarkably similar to the Silurian Perry Mountain and Smalls Falls Formations of the central Maine trough; as later mapping of the Piermont-Frontenac allochthon progressed, this correlation became increasingly compelling. Accordingly, within the limits of the Piermont-Frontenac allochthon shown on the map, rocks previously assigned to Green's (1964) Dixie Brook Member of the Dixville Formation are now assigned to the Smalls Falls Formation (Ssf), and rocks previously assigned to the immediately underlying Albee Formation of Green are now assigned to the Perry Mountain Formation (Sp).

The metavolcanic Clear Stream Member and the euxinic metasedimentary Rice Mountain Member of Green (1964) are the uppermost units exposed along the troughline of the Rice Mountain syncline of Green (1964), which extends about 50 km from Magalloway Mountain, Second Connecticut lake quadrangle, south to Dummer Hill, Percy quadrangle. On the limbs of the syncline, below the Clear Stream, are rocks now assigned (ascending order) to the Rangeley, Perry Mountain, and Smalls Falls Formations. On the basis of the structural and stratigraphic relationships shown on the map and the similarity of the euxinic Rice Mountain Member to typical rocks of the Smalls Falls Formation of other areas, both the Rice Mountain and Clear Stream are reasonably considered to belong to the Smalls Falls Formation. However, the names "Rice Mountain Member" and "Clear Stream Member" are not used on this map. Green's Rice Mountain Member is mapped as typical Smalls Falls Formation, and his Clear Stream Member is mapped as unnamed felsic volcanic lenses (Ssff) and basalt lenses (Ssfb). A mixed volcanic and sedimentary facies (Ssfv), and polymictic conglomerate lenses (Ssfc) also are mapped within the Smalls Falls Formation. The assigned Silurian age of these rocks is supported by a U-Pb zircon age of about 434 Ma (site M–2) obtained from felsic lapilli metatuff of a felsic volcanic lens; however, the reported age is probably 10–20 m.y. too old for the Smalls Falls Formation, probably because of complicated isotopic systematics resulting from inheritance from a Proterozoic source.

In the Second Connecticut Lake quadrangle and adjacent areas, Green (1968) mapped an extensive east-trending belt of rusty-weathering, gray sulfidic phyllite that he assigned to the Dixie Brook Member of the Dixville Formation. On the basis of graded bedding, these rocks were later found to lie stratigraphically below, rather than above, Green's Albee Formation (here mapped as the Dead River Formation), as described by Boudette and Boone (1976). Rocks of this belt are continuous, moreover, with the main strike belt of the Hurricane Mountain Formation, and they have all the lithic characteristics of the Hurricane Mountain. For these reasons, rocks of the northern belt of Green's Dixie Brook Member are now mapped as Hurricane Mountain Formation.

Farther north, Green (1968) named the Magalloway Member of the Dixville Formation for exposures of weakly metamorphosed, massively bedded graywacke and arkose (or quartzwacke) and smaller amounts of gray, green, and tan phyllite between the Magalloway and Little Magalloway Rivers, Parmachenee township, Maine (Green, 1968, p. 1610). Harwood (1973) included in the Magalloway Member rocks extending to the east across the northern part of the Cupsuptic quadrangle. These rocks are now recognized as a largely resedimented facies of the dacite and basalt members of the Jim Pond Formation (Ꞓjf, Ꞓjb). Because the Magalloway is a distinctive lithology within the Jim Pond Formation, the name "Magalloway Member" is retained on this map, but its affiliation is changed to the Jim Pond Formation (Ꞓjm).

*Kidderville Formation*

On the basis of mapping done since about 1980, most rocks of the Kidderville Formation of Hatch (1963) in the Dixville quadrangle, New Hampshire, are here reassigned to the Frontenac Formation of the Piermont-Frontenac allochthon, and to the Ironbound Mountain Formation. Small parts of Hatch's Kidderville Formation are also assigned to the Rangeley and Perry Mountain Formations of the allochthon. Accordingly, the name "Kidderville Formation" is not used on this map.

In the Dixville quadrangle, rocks of the Kidderville Formation of Hatch (1963) are exposed mainly east of the Monroe fault (MNF) and west of the south end of the Thrasher Peaks fault (TPF). Just east of the Monroe fault is a narrow belt of metabasalt assigned to the Frontenac Formation (Sfrb). This belt of metabasalt is overlain to the east by rocks mapped as the mixed volcanic and sedimentary facies of the Frontenac Formation (Sfrv), which in turn is underlain farther east by a thin belt of rocks assigned to the Rangeley Formation (Sr) and to the variably tuffaceous quartzite facies of the Perry Mountain Formation (Spt). Structurally, the central belt of unit Sfrv defines the troughline of a north-trending faulted syncline; these rocks represent a distal volcanic facies of the proximal bimodal volcanic facies of the Frontenac Formation (Sfrx), exposed onstrike to the northeast. The easternmost belt of Hatch's Kidderville Formation contains gray slate identical to that of the type Ironbound Mountain Formation (see note 6); it also contains, in ascending order, the magnetite-bearing siltstone and shale facies (Dsim), the felsic volcanic member (Dsif), and the euxinic shale member (Dsie) of the Ironbound Mountain Formation.

**Note 5.**—The proposal of Pollock (1987) to raise the Seboomook Formation (Osberg and others, 1985) to group rank is adopted for use on this map. Within the area of this map, Pollock's proposed Seboomook Group contains the formally introduced Ironbound Mountain Formation (Dsi) (see note 6) in the Connecticut Valley trough, and the Carrabassett (Dsc) and Hildreths (Dsh) Formations, and the Mount Blue (Dsm), Temple Stream (Dst), and Day Mountain (Dsd) Formations (members of the former Seboomook Formation here raised to formation rank; see note 8) in the central Maine trough. Unnamed or informally named units in the group are the upper shale and sandstone (Dsu), which overlies the Ironbound Mountain Formation in northwestern Maine, and the shale and sandstone (Dss), greenstone at Camera Hill (Dsch), and well-bedded shale and sandstone (Dsw). Fossils recovered from many localities in the Seboomook Group of the Moose River synclinorium (Boucot and Heath, 1969, p. 34, 35), and from the Temiscouata Formation (equivalent to the Seboomook) in northwestern New Brunswick (St. Peter and Boucot, 1981) indicate a late Gedinnian(?), Siegenian, and Emsian age.

Pollock (1987, fig. 1) assigned the rocks at the former type section of the Seboomook Formation of Boucot (1961) to his Northeast Carry Formation; the type section is about 22 km east of the eastern margin of the Penobscot Lake quadrangle. As shown on Pollock's map (1987, fig. 1), the Northeast Carry Formation is not known to extend into the area of this map, but it occurs within a much larger area of undivided shale and sandstone (Dss) that extends into the map area. This shale and sandstone unit contains the Camera Hill Greenstone Member of Boucot (1961); because of its small areal extent, this member is here designated as greenstone at Camera Hill (Dsch). The well-bedded shale and sandstone (Dsw), which contains about equal amounts of metasandstone and slate, occurs within more pelitic rocks of the Seboomook Group. Further mapping is needed to determine if these well-bedded rocks constitute a more extensive formation in their own right.

**Note 6.**—The Ironbound Mountain Formation of Marvinney (1982, 1986) and Osberg and others (1985) is here formally introduced in the Sherbrooke-Lewiston area as the basal unit of the Seboomook Group in northwestern Maine (Pollock, 1987) (see note 5). On this map the Ironbound Mountain Formation is mapped on opposite limbs of a broad, faulted, structurally complex anticlinorial belt underlain by Silurian rocks assigned to the Frontenac Formation extending from the Penobscot Lake quadrangle in northeastern Maine, to the Averill quadrangle in northeastern Vermont. The Ironbound Mountain Formation of this belt is conformably underlain by the Frontenac Formation. Small remnants of the Ironbound Mountain Formation are conformably to possibly unconformably underlain by the Madrid, Smalls Falls. and Perry Mountain Formations of the Piermont sequence in the Piermont-Frontenac allochthon. Lithologic descriptions are provided in the Description of Map Units. The Ironbound Mountain Formation is correlated with the Carrabassett Formation, which is the basal unit of the Seboomook Group in the central Maine trough, and it is tentatively correlated with the Meetinghouse Slate Member of the Gile Mountain Formation in the Connecticut Valley trough.

Marvinney (1986) used the name "Ironbound Mountain Formation" for exposures of thinly bedded, medium- to dark-gray and olive-gray slaty mudstone and siltstone on Ironbound Mountain, a prominent northeast-trending ridge in the southeast corner of the Penobscot Lake quadrangle. The formation crops out in a belt that is 4–5 km wide and extends northeastward from Ironbound Mountain across the Seboomook Lake quadrangle, and southwestward into the Long Pond quadrangle, where the formation is truncated by the Thrasher Peaks fault. In the Penobscot Lake quadrangle, characteristic rocks of the Ironbound Mountain can be seen at Ironbound Pond and Ironbound Mountain. In the Seboomook Lake quadrangle, the formation is particularly well exposed along the road from Pittston Farm, at the west end of Penobscot Lake, to Rockwood, in the Brassua Lake quadrangle (east of the Long Pond quadrangle). The type locality is here designated as a 2-km length of this road between two bench marks at elevation 1,402 ft; the northern bench mark is about 5 km southeast of Pittston Farm.

The Ironbound Mountain Formation is conformably overlain by upper shale and sandstone of the Seboomook Group (Dsu). In the Penobscot Lake quadrangle, the Ironbound Mountain Formation is conformably underlain by metasedimentary rocks of the Frontenac Formation (Sfr) and locally by basalt lenses of the Frontenac (Sfrb). Where underlain by metasedimentary rocks of the Frontenac Formation, the contact is gradational by interbedding through a stratigraphic interval as much as 250 m thick. In Vermont and New Hampshire, the formation is conformably underlain by rocks of the western facies of the Frontenac Formation (Sfrws, Sfrwg, Sfrwh), and it is conformably to possibly unconformably underlain by remnants of the Madrid Formation (Sm), and by facies of the Smalls Falls (Ssf, Ssfv) and Perry Mountain (Spt, Spvs) Formations.

The Ironbound Mountain Formation has not yielded fossils but is considered to be Early Devonian in age on the basis of its lithologic similarity to fossil-dated Lower Devonian gray slate and metasandstone of the Seboomook Group and Littleton Formation in Maine and New Hampshire. This assignment is supported by relationships exposed on Mud Pond Ridge, Dixville quadrangle, where gray slate that is identical to typical rocks of the Ironbound Mountain Formation at its type locality is conformably underlain by thickly bedded, calcareous, feldspathic metasandstone and calc-silicate rock assigned to the uppermost Silurian(?) Madrid Formation.

Marvinney (1986) named the Grenier Ponds Member of the Ironbound Mountain Formation for exposures of thickly interbedded quartzose, lithic metasandstone, and gray slate near Middle Grenier Pond, Sandy Bay quadrangle, and Big Grenier Pond, Penobscot Lake quadrangle, Maine. He described a type locality for the member and gave its location as about 2 km east of Big Grenier Pond, along a logging road in a small valley that lies just southwest of Hill 1915, Penobscot Lake quadrangle. Outcrops here are accessible by traveling logging roads about 4.7 km southwest from the north end of Long Pond, in the Penobscot Lake quadrangle. Marvinney (1986) correlated the type Grenier Ponds with extensive exposures of similar rocks outside the map area, about 35 km to the east, on the opposite side of the anticlinorial belt underlain by rocks of the Frontenac Formation (Sfr). Here, arenaceous rocks that strongly resemble those of the type Grenier Ponds Member grade laterally southwestward into typical pelitic rocks of the Ironbound Mountain Formation; these arenaceous rocks also grade downward into rocks of the Frontenac Formation.

The Grenier Ponds Member of Marvinney (1986) is here adopted for use on this map. However, the name of the member is changed to Grenier Ponds Grit Member, in order to emphasize its essential character. Nearly identical lenses of grit, shown on this map as grit lenses at Halls Stream (Dsih), are exposed within the Ironbound Mountain Formation near the Vermont–Quebec–New Hampshire border and on Townsend Mountain and Mount Misery at the northeast corner of the Littleton quadrangle; additionally, the felsic volcanic member of the Ironbound Mountain Formation contains abundant grit beds of similar character.

**Note 7.**—This note redefines the Piermont allochthon of Moench and others (1987) and Moench (1992, and references therein) according to usage that is applied in this publication and briefly describes the Second Lake rift.

*Piermont-Frontenac allochthon*

The Piermont allochthon of previous usage is here termed the Piermont-Frontenac allochthon, and is restricted to pre-Early Devonian formations of the Second Lake rift exposed west of the Monroe–Foster Hill–Thrasher Peaks line (fig. 3, M–F–T). No major structural dislocation can now be identified that might be taken to mark the western boundary of the allochthon. Instead, recent mapping indicates that rocks now included in the allochthon belong to the Connecticut Valley trough (fig. 3; CVT)

"Piermont-Frontenac allochthon" is a structural term that encompasses the Silurian rift and possibly slightly older pre-rift sequences of the Second Lake rift (Moench and others, 1992) that are interpreted to be allochthonous relative to the rocks of the Bronson Hill–Boundary Mountains anticlinorium. The sequences of the Second Lake rift include a western rift sequence (mainly Frontenac Formation, but also tentatively the Ayers Cliff and Waits River Formations), mainly west of the rift axis (fig. 3, SLRA), and the Piermont sequence (the possibly pre-rift Quimby, Greenvale Cove, and Rangeley Formations, and the syn-rift, Perry Mountain, Smalls Falls and Madrid Formations), east of the axis. Moench (1992, and references therein) showed that the rocks of the Piermont sequence are allochthonous, having a source in some part of the central Maine trough (fig. 3, CMT). The western rift sequence also appears to be allochthonous, because recent mapping has shown that the Frontenac and Perry Mountain Formations, respectively of the western and Piermont sequences, are lateral facies of one another. Although the direction, amount, and mechanism of transport have not been determined, mapping and U-Pb zircon age data for the Piermont, New Hampshire, area (fig. 3) indicate that transport probably occurred in latest Silurian to earliest Devonian time.

Near Piermont, as shown by (Moench, 1990), the juxtaposed allochthonous and autochthonous rocks are both intruded (stitched) by the granitic Fairlee pluton (index 94), which has been dated at 410±5 Ma (site D–9). This age overlaps the Silurian-Devonian boundary of Harland and others (1989; 408.5 Ma), if correct, with a margin of error that overlaps no later than the early part of Gedinnian time (Harland and others, 1989, fig. 3.5).

These relationships suggest that the allochthon was emplaced no later than Gedinnian time, and certainly well before deposition of that part of the Compton Formation that contains Emsian plant remains (about 390 Ma on fig. 3.5 of Harland and others, 1989), and no later than those parts of the Seboomook Group that contain Siegenian fossils. Accordingly, the Compton Formation, the upper part of the Seboomook Group, and probably the Gile Mountain Formation (possibly except the Meetinghouse Slate Member) can be considered as an autochthonous cover sequence that was spread over the Piermont-Frontenac allocthon after emplacement. Earliest Devonian deposition of the Ironbound Mountain Formation, however (and possibly the Meetinghouse Slate Member), quickly followed Silurian and Silurian(?) deposition of the Frontenac and Madrid Formations of the allochthon and is reasonably considered to be composed of parallochthonous sediments that accumulated over the allochthon while in transit.

*Second Lake rift*

Recent mapping in the Guildhall quadrangle indicates that the formations of the Piermont sequence and the Frontenac Formation are structurally and stratigraphically tied together. Moench and others (1992) called this belt the Second Lake rift, and they proposed that the approximate axis of the rift (fig. 3; SLRA) originated as a magmatic, sea-floor spreading ridge that effectively separated a western basin of deposition of the Frontenac Formation from an eastern basin of deposition of most of the Perry Mountain, Smalls Falls, and Madrid Formations. The Second Lake rift axis coincides with the Second Lake anticline of Harwood (1969). Whereas Harwood suggested that his proposed anticline is cored by predominantly metavolcanic Ordovician rocks that are unconformably flanked by predominantly metasedimentary Devonian rocks, available evidence indicates that Harwood's proposed unconformity is a conformity and that all these rocks are Silurian and approximately coeval. As shown at the northwest end of section *C–C′*, the belt is broadly anticlinal, but it is "creased" lengthwise by a tight faulted syncline. When restored to approximate positions that are likely to have existed before tight folding, the "creased" anticline would have the form of a subaqueous spreading ridge with an axial half-graben. The inferred half-graben was the locus of intensive bimodal volcanism, represented by the rocks mapped as the proximal bimodal facies of the Frontenac Formation (Sfrx); it was also the locus of sea-floor mineralization represented by massive sulfide deposits at Ledge Ridge Maine, and in the Clinton River district, Quebec (Moench, 1990). Intrusive and volcanic rocks of basaltic composition in the rift have chemical characteristics of basaltic magma erupted in areas undergoing tectonic extension (for example, Chevé and others, 1983; Eisenberg, 1983; Ebinger, 1985; Chevé, 1990).

The subaqueous ridge was probably most active, and thus probably topographically highest, in the belt that contains the most proximal bimodal volcanic rocks, between the northeast corner of the Dixville quadrangle, New Hampshire, and the Spider Lake pluton (index 7), Quebec. Accordingly, the two basins were probably most cleanly separated in this area. However, between the Gore Mountain plutons (index 43) and Gardner Mountain, at the west side of the Littleton quadrangle, there is evidence of only small scattered volcanic centers in rocks now mapped as volcanic facies of the Perry Mountain and Smalls Falls Formations. The ridge might therefore have been much lower in this area, allowing sedimentary communication between the two basins. This is probably the reason that metasedimentary rocks of the Perry Mountain and Frontenac Formations laterally intergrade in the Guildhall quadrangle, west of the probable trend of the Second Lake rift axis (fig. 3). Northeast of the Spider Lake pluton the rift axis might be represented by greenstone lenses mapped in Quebec and by abundantly pillowed greenstone mapped in the Penobscot Lake quadrangle, Maine, by Marvinney (1986) as the Canada Falls Member (name not used in this publication) of the Frontenac Formation. The fact that metasedimentary rocks of the Frontenac Formation occur on both sides of this possible northern continuation of the rift axis might indicate that the axis and both basins were flooded by Frontenac sediments in this area.

**Note 8.**—The proposal of Pollock (1987) to raise the Seboomook Formation to group rank (see note 5) necessitates elevating the Mount Blue, Temple Stream, and Day Mountain Members of Pankiwskyj (1979) and Moench and Pankiwskyj (1988a) in the Kingfield and Anson quadrangles, Maine, to formation rank.

*Day Mountain Formation (Dsd)*

Pankiwskyj (1979, p. 34–39) named the Day Mountain Member of the Seboomook Formation for cyclically interbedded dark-gray, pelitic schist and lighter gray, graded metasiltstone and feldspathic metasandstone exposed on Day Mountain, at the southeast corner of the Phillips quadrangle, Maine. This member is raised in rank to the Day Mountain Formation, following the usage of Pollock (1987). Good exposures on the north ridge and southeastern slope of Day Mountain make up the type locality. Spectacular exposures can be seen on the northeast slope and summit of Bald Mountain, about 8 km southeast of Weld, Maine, Dixfield quadrangle; access is by means of a much-used trail that leads southwest from Maine Route 156.

Most of the Day Mountain Formation has the style of cyclic graded bedding that characterizes most of the Seboomook Group and Littleton Formation throughout the area of this map. In the area underlain by known Day Mountain, the principal part of the formation (Dsd) coarsens laterally southeastward from about equal proportions of metashale and coarser grained detritus in northwestern areas to about 80 percent metasandstone (or metagraywacke) in southeastern areas.

Mapped separately from the principal part are two unnamed members, or lenses. Granule conglomerate lenses (Dsdg) contain abundant thick, graded beds of coarse-grained metasandstone and quartz-rich polymictic granule metaconglomerate interstratified with characteristic rocks of the principal part. These lenses are as much as 350 m thick, and they occur only in southeastern parts of the area underlain by the Day Mountain Formation. Impure limestone lenses (Dsdl) occur in the northwestern and southeastern areas. They are composed of thinly interbedded light-gray, arenaceous metalimestone and calcareous metasiltstone, and subordinate beds of dark-gray pelitic schist; rusty-weathering, sulfidic, dark-gray metasandstone is locally abundant. The lenses of impure limestone are as much as 250 m thick.

The Day Mountain Formation is at least 1,000 m thick, but the upper part has been eroded. The contact with the underlying Temple Stream Formation (Dst) is gradational, and the lower part of the Day Mountain is inferred to intertongue with the upper part of the Temple Stream.

*Temple Stream Formation (Dst)*

Pankiwskyj (1979, p. 31–34) named the Temple Stream Member of the Seboomook Formation for exposures of rusty-weathering metasedimentary rocks along Temple Stream, in the northeastern corner of the Dixfield quadrangle, Maine. The member is raised in rank to the Temple Stream Formation, following the usage of Pollock (1987). The type locality is between the elevations of 730 ft and 790 ft along Temple Stream.

The Temple Stream Formation characteristically contains visible pyrrhotite or pyrite. The unit is composed of interstratified graded beds of noncalcareous to strongly calcareous, resistant to punky-weathering metasandstone and metasiltstone, interbeds of dark-gray to black graphitic schist, and thin to very thick beds of quartz-rich, polymictic granule metaconglomerate.

The Temple Stream Formation is about 250 m thick. Its contact with the underlying Mount Blue Formation (Dsm) is gradational; the contact is marked by abruptly gradational downward decreases in the amount of pyrrhotite or pyrite and the rustiness of weathering. The basal several meters of the Temple Stream has the characteristic cyclic graded bedding style of the underlying Mount Blue Formation.

*Mount Blue Formation (Dsm)*

Pankiwskyj (1979, p. 29–31) named the Mount Blue Member of the Seboomook Group for cyclically graded beds of dark-gray pelitic schist and lighter gray metasiltstone exposed on Mount Blue, a prominent peak in the north-central part of the Dixfield quadrangle, Maine. The member is raised in rank to the Mount Blue Formation, following the usage of Pollock (1987). The type locality is the summit of Mount Blue.

The Mount Blue Formation is composed mainly of cyclically interbedded metashale and metasiltstone, typically in graded beds that range from 2 to 5 cm thick; ratios of metashale to metasiltstone range from 1:1 to 2:1. Also present are sequences of massive or only faintly bedded, dark-gray metashale, and arenaceous sequences having graded beds of white-weathering metasandstone as much as 1 m thick that are separated by thinner beds of metasiltstone and metashale. The thick metasandstone beds commonly display small-scale cross- and convolute-laminations. Schist of the lower part of the Mount Blue tends to be rustier weathering and darker gray than the majority of the formation, owing to the presence of pyrrhotite and graphite.

The Mount Blue Formation is approximately 500–750 m thick. The contact of the Mount Blue with the underlying Hildreths Formation (Dsh) of the Seboomook Group is sharp and conformable.

**Note 9.**—Marvinney (1984) named The Forks Formation (Stf) for weakly metamorphosed thickly bedded sandstone, about 120 m thick, and underlying siltstone and thinly bedded silty limestone, about 95 m thick, exposed near the village of The Forks, Maine, just east of the map area. This formation was shown by Osberg and others (1985) within the map area and to the east, and is adopted for this publication. Boone (1973) previously mapped the same rocks as "unnamed calcareous phyllite and related rocks" in the Little Bigelow Mountain quadrangle and adjacent areas, Maine, and his usage was followed by Moench and Pankiwskyj (1988a). Marvinney (1984, p. 154) defined a composite type locality for The Forks Formation that consists of two reference sections near The Forks village, Maine. The contact of the formation with the underlying Dead River Formation (O€d) is locally marked by several centimeters of polymictic conglomerate and is interpreted as an unconformity. The contact with overlying massive gray slate of the Carrabassett Formation (Dc) is gradational by interbedding through about 20 m of section. The basal layer of The Forks Formation locally contains shelly fossils, but so far no diagnostic forms have been identified. The Forks Formation is considered to be coeval with the Madrid Formation (Sm) on the basis of lithologic similarity and the conformable position of both formations below the Carrabassett Formation. The Forks Formation, which unconformably overlies pre-Silurian rocks, is interpreted to be a shoreline facies of the Madrid, which conformably overlies a thick sequence of older Ordovician and Silurian rocks. On the basis of this correlation, the age of The Forks Formation is modified from the Late Silurian age assigned by Marvinney (1984) to Silurian(?) (Ludlovian? and Pridolian?).

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