The Quimby and Greenvale Cove Formations in Western Maine

By ROBERT H. MOENCH

CONTRIBUTIONS TO STRATIGRAPHY

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Clastic metasedimentary rocks of Late Ordovician(?) age are described and newly named

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THE QUIMBY AND GREENVALE COVE FORMATIONS IN WESTERN MAINE

By ROBERT H. MOENCH

ABSTRACT

The newly named formations, the Quimby and the Greenvale Cove, in Franklin County, Maine, are composed of clastic metasedimentary rocks of Late Ordovician (?) age. The Quimby Formation is about 3,000 feet thick; it conformably overlies the Dixville Formation of Middle Ordovician age. The Quimby consists of two members. The graywacke member is composed of thick-bedded metagraywacke and conglomeratic metagraywacke, a subordinate amount of sulfidic metashale, and sparse rhyolitic metavolcanic rocks. The overlying shale member is composed of gray or black commonly sulfidic metashale and a subordinate amount of metagraywacke. The Quimby Formation is a turbidite-shale sequence that was deposited in a euxinic marine environment.

The Greenvale Cove Formation conformably overlies the Quimby and is itself conformably overlain by the more coarsely clastic Rangeley Formation of Early Silurian (?) age. The Greenvale Cove is 300–600 feet thick. It is composed of interlaminated light-gray metasandstone, metasiltstone, and metashale. In the southern part of the report area light-colored laminated calc-silicate rocks are abundant in the upper part of the formation. Characteristics of the rocks suggest that they were deposited in a non-euxinic marine environment which was characterized by active traction currents.

Before the Taconic disturbance, the Quimby and Greenvale Cove Formations or their equivalents may have been widespread in New England and southeastern Quebec, but if they were, they were removed throughout much of the region by the erosion that accompanied the disturbance. Probable age equivalents to the Quimby and Greenvale Cove Formations are (1) the Upper Ordovician(?) Sherbrooke Formation, exposed in Quebec about 80 miles northwest of the Rangeley area; and (2) part of the Middle Ordovician to Lower Silurian Carys Mills Formation, exposed in northern Maine about 180–200 miles northeast of Rangeley.

INTRODUCTION

A lithologically varied section of eugeosynclinal rocks and subordinate amounts of miogeosynclinal rocks of Ordovician, Ordovician(?), Silurian(?), and Devonian(?) age has been mapped since 1960 in the Rangeley and Phillips quadrangles in western Maine (figs. 1, 2). This section is at least 30,000 feet thick, not including the older metasedi-

mentary and metavolcanic rocks that are exposed to the northwest (Green, 1964; Harwood and Berry, 1967) or the younger rocks to the southeast (Osberg and others, 1968). Most of the exposed formations in the Rangeley and Phillips quadrangles have been described briefly and have been assigned names in a separate report (Osberg and others, 1968). Upper Ordovician(?) rocks described in that report were not named, however, and are named herein the Quimby and Greenvale Cove Formations. The distribution of these rocks is shown in figure 2.

The Quimby and Greenvale Cove Formations correspond to the northern argillite of Smith (1923), a mass of dominantly pelitic rocks that Smith correctly recognized as being stratigraphically below the Rangeley Conglomerate. The Rangeley Conglomerate of Smith (1923) has since been redefined as the lower part of the Rangeley Formation (Osberg and others, 1968).

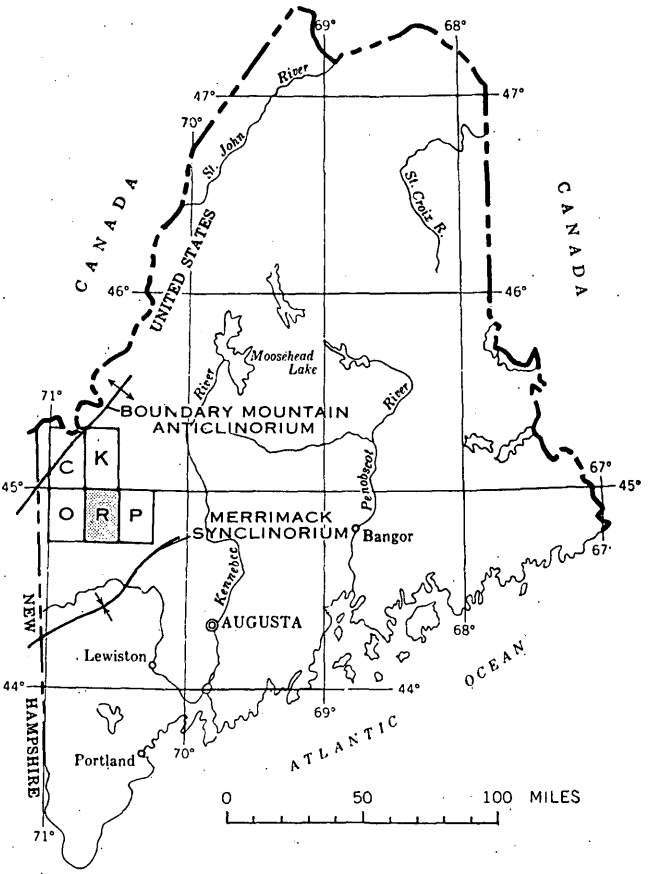


FIGURE 1.—Location of report area (stippled). Quadrangles: R, Rangeley; P, Phillips; K, Kennebago Lake; O, Oquossoc; C, Cupsuptic.

GEOLOGIC SETTING

Metasedimentary rocks of the Phillips and Rangeley quadrangles define nearly the full width of the Merrimack synclinorium in western Maine (Osberg and others, 1968, fig. 1). Immediately to the northwest is the Boundary Mountain anticlinorium. In the area of the anticlinorium, tightly folded Middle Ordovician and older rocks are unconformably overlain by less deformed Silurian and Devonian rocks (Harwood and Berry, 1967). This unconformity, the Taconic, is represented in the Rangeley quadrangle by a conformable contact between fine-grained clastic Upper Ordovician (?) rocks and generally more coarsely clastic Lower Silurian(?) rocks. All other sedimentary contacts in the area are similarly conformable. Rocks of probable Silurian age in the Rangeley and Phillips quadrangles are nearly 15,000 feet thick—far thicker than rocks of equivalent age to the northwest (Osberg and others, 1968). Moreover, an additional 3,500 feet of Upper Ordovician(?) clastic rocks are exposed in the Rangeley quadrangle but are apparently absent from the core of the Boundary Mountain anticlinorium. These rocks—the Quimby and Greenvale Cove Formations—lie between the Dixville Formation of Middle Ordovician age (Harwood and Berry, 1967) [1] and the Rangeley Formation of Early Silurian(?) age (see p. L14).

Metasedimentary rocks of the Rangeley quadrangle have been tightly folded along northeast-trending axes, have been faulted, metamorphosed, intruded by large plutons, and have been further deformed and metamorphosed at places near the borders of the large plutons. The Brimstone Mountain anticline dominates the structure of the central part of the Rangeley quadrangle (fig. 2); its axial surface and associated phyllitic cleavage and schistosity dip steeply; its axis plunges northeast near Long Pond, but is subhorizontal farther southwest (fig. 2). The Quimby and Greenvale Cove Formations define the core of the anticline. Here, these rocks are in the staurolite and sillimanite grades of metamorphism (fig. 2); they have been deformed by tight minor folds of the Brimstone Mountain anticline and further deformed by late generations of slip cleavage, schistosity, and accompanying small nearly recumbent folds. Despite this intense deformation and metamorphism the fine details of sedimentary structural features are commonly visible. These features and the sequence of lithologies are the bases for the correlation of the Quimby and Greenvale Cove Formations in the Brimstone Mountain anticline with the formations near Rangeley Lake (fig. 2).

[1] Harwood and Berry (1967) correlated the graptolite-bearing black slates and associated greenstone in the southeast corner of the Cupsuptic quadrangle with the Dixville Formation (Green, 1964) and with the Partridge and Ammonoosuc Formations (Billings, 1956). Osberg, Moench, and Warner (1968) extended the usage of the name Dixville Formation to the rocks of the northwest corner of the Rangeley quadrangle.

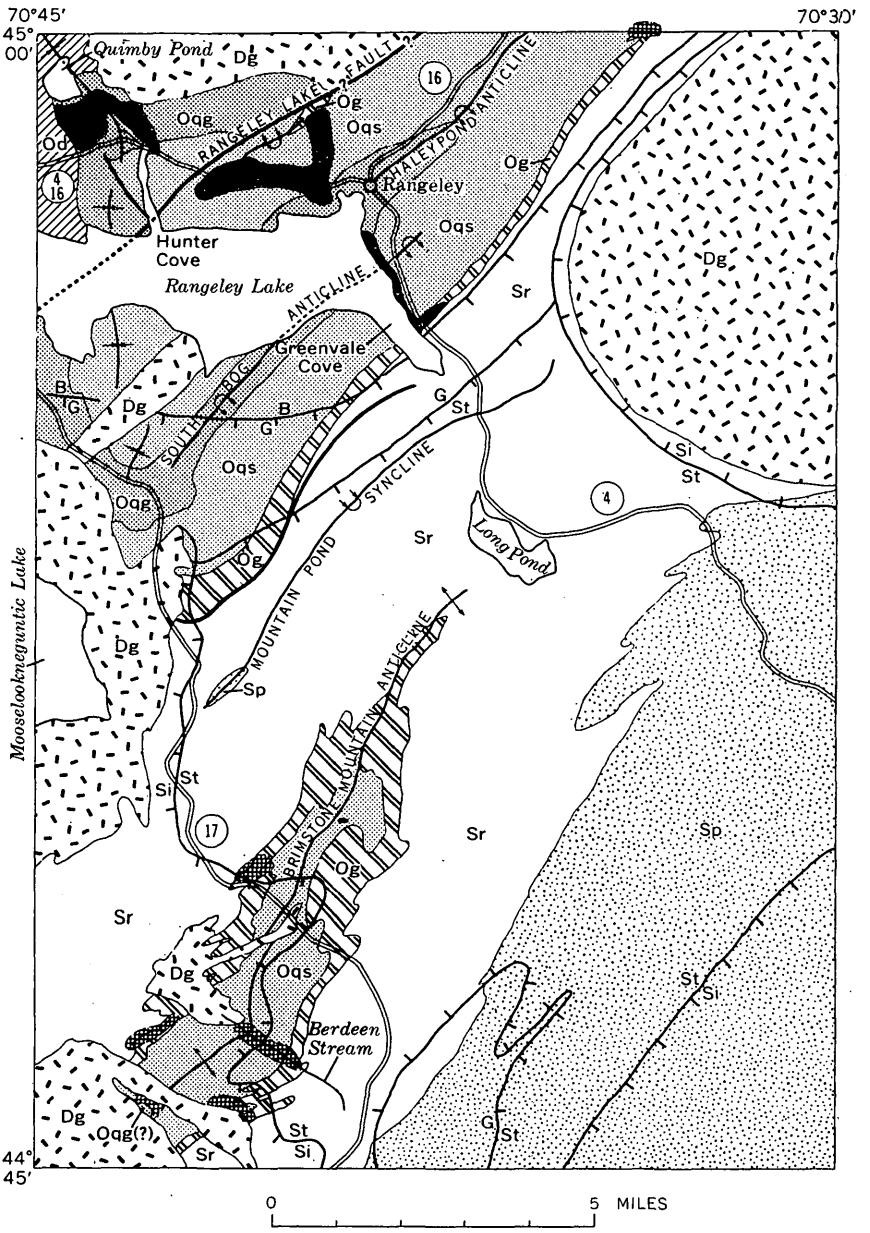
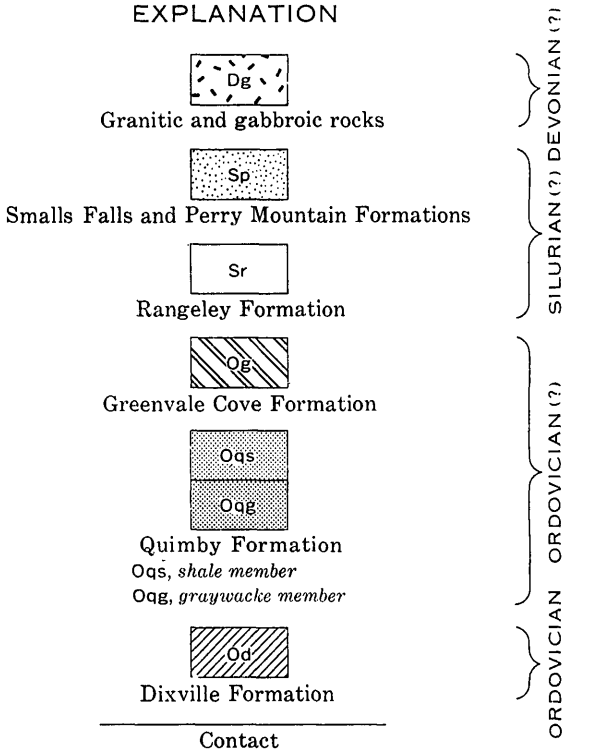


FIGURE 2.—Generalized geologic map of the Rangeley quadrangle. (Map explanation shown on facing page.)


EXPLANATION
Dg
Granitic and gabbroic rocks
Sp
Smalls Falls and Perry Mountain Formations
Sr
Rangeley Formation
Og
Greenvale Cove Formation
Oqs
Oqg
Quimby Formation
Oqs, shale member
Oqg, graywacke member
Od
Dixville Formation
SILURIAN (?) DEVONIAN (?)
ORDOVICIAN (?)
ORDOVICIAN
Contact
Fault
Dotted where concealed; queried where conjectural
Anticline
Overturned anticline
Syncline
Overturned syncline
Folds
Showing trace of axial surface
B
G
G
St
St
Si
Metamorphic isograds
B, biotite and chlorite zones undivided
G, garnet zone
St, staurolite zone
Si, sillimanite zone
Type locality of Greenvale Cove Formation and type area of Quimby Formation
Additional areas from which data were obtained for figure 3

The major tectonic structural features near Rangeley Lake are the Haley Pond and South Bog overturned anticlines and the Rangeley Lake fault (fig. 2). In addition, an open north-northwest-trending syncline has been superposed on the northeast-trending overturned folds. This superposition is indicated by the deflected outcrop patterns of the graywacke member of the Quimby Formation (fig. 2) and by the change in strike of the slaty and phyllitic cleavage(which is subparallel to the axial surfaces of the overturned folds) from east-northeast on the east side of the troughline to north-northwest on the west side. The rocks in the area around Rangeley Lake are generally in the chlorite, biotite, and garnet zones of metamorphism, and the rocks have a slaty or phyllitic cleavage, as well as younger generations of slip cleavage. Relict sedimentary textures and fine details of sedimentary structural features, however, are commonly visible.

QUIMBY FORMATION

The Quimby Formation is here named for exposures of metamorphosed graywacke [2] (henceforth called metagraywacke) and slate between Quimby Pond and Hunter Cove, which is a narrow embayment on the north side of Rangeley Lake (fig. 2). Here the formation crops out in roadcuts, on low hills, and along Quimby Brook, which flows from Quimby Pond to Hunter Cove. These exposures represent only the lower part of the formation; equivalent and higher parts of the formation crop out elsewhere along the shores of Rangeley Lake, on nearby hills, and along tributary brooks. Exposures of the upper and lower parts of the formation near Rangeley Lake are designated the type area (fig. 2).

Two stratigraphic columns representing the Quimby Formation are shown in figure 3. The column representing the Rangeley area was compiled principally from data obtained from the type area (fig. 2). The column representing the Brimstone Mountain anticline area was compiled principally from exposures along Berdeen Stream and from two smaller areas farther southwest (fig. 2). In both the Rangeley area and the Brimstone Mountain anticline, rocks of the Quimby are

[2] In this report the term "graywacke" is used in the broad sense for unsorted sandstone composed of angular fragments of feldspar, rock fragments, and quartz set in a detrital argillaceous matrix. On figure 96 of Williams, Turner, and Gilbert (1954) the metamorphosed graywacke of the Rangeley area would plot near the boundary between arkosic and lithic wackes. Despite thorough recrystallization, at low metamorphic grade in the Rangeley area, the characteristic graywacke texture is well preserved. Toward higher metamorphic grades, the rocks become equigranular granofels. At all metamorphic grades in the area, modal analyses indicate 20–30 percent quartz; 30–45 percent plagioclase (albite-oligoclase, commonly untwinned); 25–40 percent biotite and (or) chlorite, and subordinate amounts of muscovite; a few percent of staurolite, garnet, calcite, and clinozoisite may be present as well. Clay minerals and potassium feldspar were undoubtedly present in the original sediments, but were converted during low-grade metamorphism to chlorite and micas.

complexly folded and incompletely exposed. Correlation, therefore, of minor stratigraphic zones between the two areas is tenuous.

The Quimby Formation is divisible into (1) a lower graywacke member composed largely of thick-bedded metagraywacke and subordinate amounts of interbedded felsic metavolcanic rocks and metashale and (2) an upper shale member composed of thin-bedded metashale and subordinate amounts or locally abundant metagraywacke and sparse felsic metavolcanic rocks (fig. 3).

GRAYWACKE MEMBER

The graywacke member of the Quimby Formation is composed of interbedded metagraywacke, conglomeratic metagraywacke, and subordinate amounts of metashale and felsic volcanic rocks. The metagraywacke is medium light gray to light brownish gray; it typically weathers to cream color but locally weathers to rust color. It forms graded beds that are typically 6 inches to 5 feet thick, some of which are separated by thin partings or beds of metashale. Commonly the graded beds are massive, but locally they show parallel laminations. Crossbedding is rare. In areas of low metamorphic grade, the metagraywacke is composed of angular unsorted fine-grained to very coarse grained sand-sized fragments of sodic plagioclase, rock fragments, and subordinate amounts of quartz, set in a matrix of chlorite, sericite, and local biotite. Some of the larger grains are myrmekitic intergrowths of quartz and plagioclase. Calcite and calc-silicate minerals are common, but they rarely form more than 1–2 percent of the rock. Despite low-grade metamorphism, the primary graywacke texture is well preserved. A modal analysis (point count) of one specimen of typical metagraywacke showed 28 percent quartz, 43 percent plagioclase, 18 percent biotite, 6 percent chlorite, 2 percent muscovite, 1 percent opaque mineral, and about 2 percent sphene, apatite, clinozoisite, and calcite.

Many of the thicker beds of metagraywacke contain abundant thin chips of dark-gray slate. Some beds are polymictic metaconglomerate that contains abundant granules, pebbles, and small cobbles of metamorphosed shale, siltstone, quartzite, vein quartz, dense white felsic volcanic rocks, and sparse dark-green mafic volcanic rocks. The granules and larger fragments are set in a matrix of typical metagraywacke. In all conglomeratic rocks the spaces between the conglomerate fragments are completely filled with metagraywacke, but the proportion of matrix to conglomerate fragments is extremely variable. The clasts of coarsely crystalline vein quartz are equant and are generally less than half an inch across. Most other clasts are thinly tabular with rounded to angular edges, and many are extremely elongate. The tabular clasts are alined parallel to schistosity; the elongate clasts are alined parallel

RANGELEY AREA

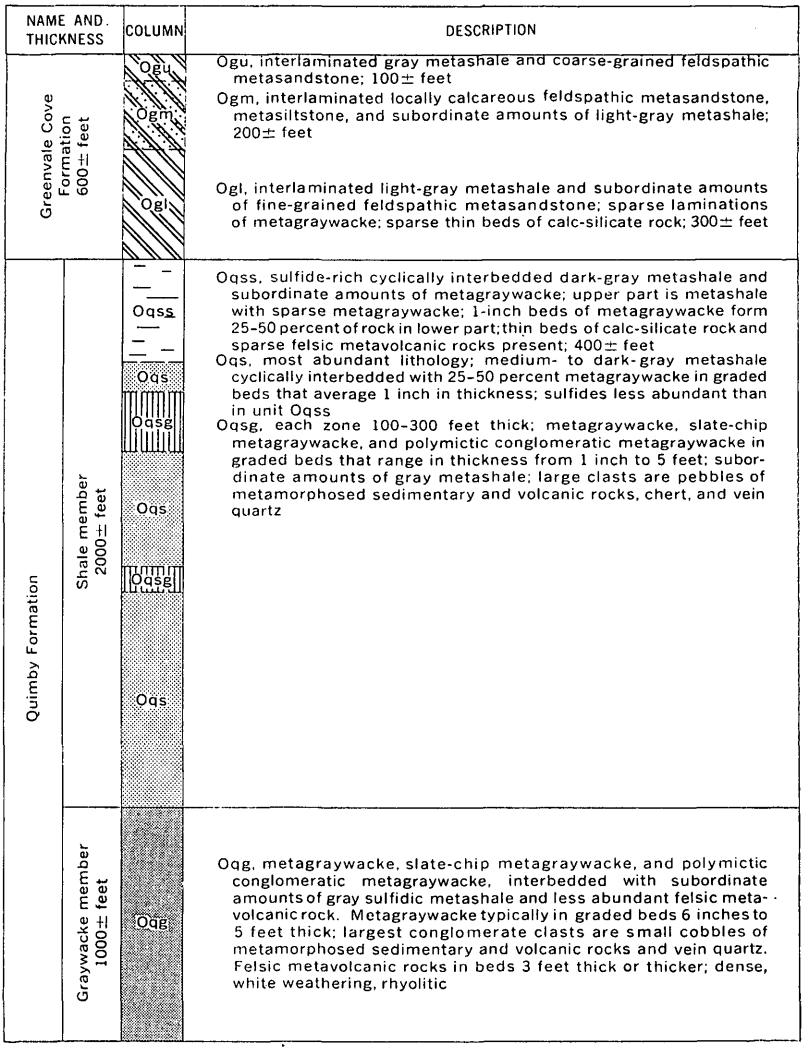
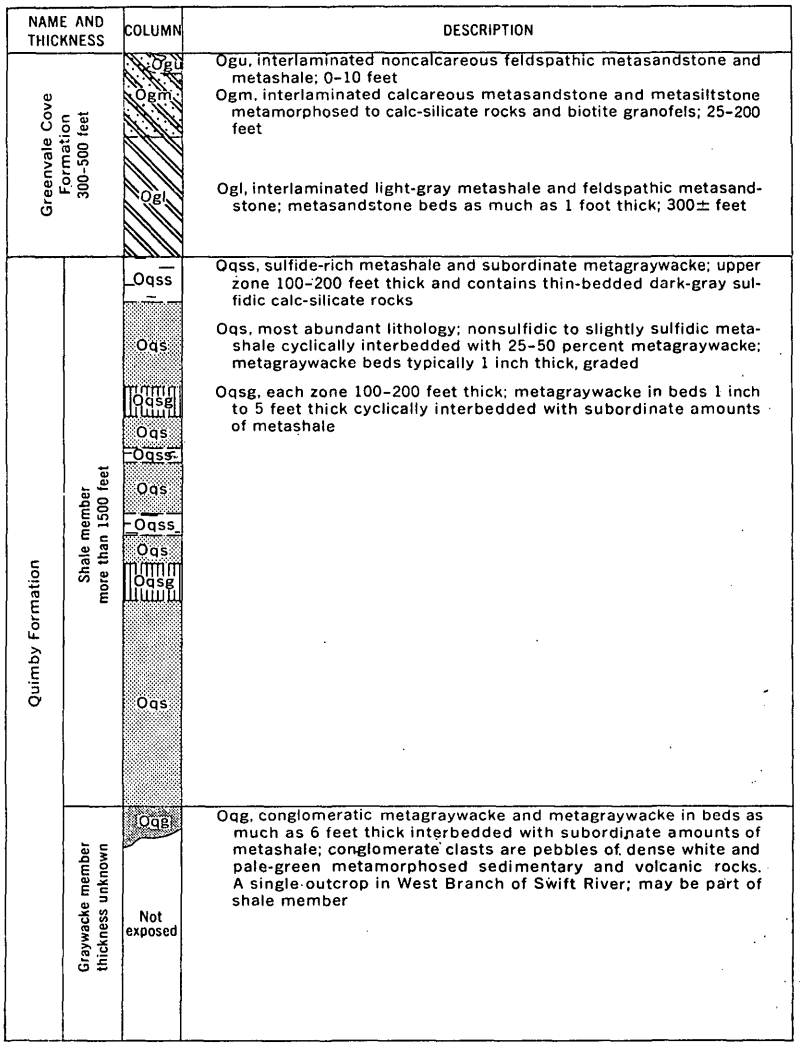


FIGURE 3.—Stratigraphic columns of the Quimby and Greenvale Cove

AREA OF BRIMSTONE MOUNTAIN ANTICLINE



Formations. Rangeley area and area of Brimstone Mountain anticline.

to one another and define a conspicuous lineation. The felsic volcanic rock fragments are composed of fine-grained oligoclase, subordinate amounts of quartz, and smaller amounts of muscovite and biotite; a few volcanic rocks contain small randomly oriented tabular phenocrysts of oligoclase. The quartzite fragments are composed of 75–90 percent well-sorted fine-grained quartz, 5–15 percent biotite, and minor amounts of oligoclase. These rock types were derived from a sedimentary and volcanic terrane.

The metashale interbedded with the metagraywacke is medium-gray and dark-gray sulfidic slate and phyllite.

Felsic metavolcanic rock was identified in two outcrops, where it forms, respectively, a layer about 3 feet thick and a thicker layer of unknown thickness. Such rocks may be more abundant in the graywacke member than is now recognized. The felsic rock is lighter gray than the associated metagraywacke; it is dense to fine grained and faintly banded. One specimen examined in thin section may be classed metarhyolite; it contains about 35 percent quartz, 34 percent potassium feldspar, 8 percent altered calcic oligoclase, 17 percent muscovite, 3 percent biotite, and 3 percent clinozoisite and subordinate accessory minerals. The quartz and feldspars are fine grained, equigranular, anhedral, and interlocking; the micas are evenly distributed and are alined parallel to the phyllitic cleavage. Unlike the associated beds of metagraywacke in the same outcrop, the felsic metavolcanic rocks show no evidence of an originally clastic texture.

The lower contact of the graywacke member is poorly exposed, but it is probably gradational and conformable, because rocks that are characteristic of the Quimby and Dixville Formations are present in smaller abundances on opposite sides of the contact. The contact is placed arbitrarily where the alternating 1- to 3-inch beds of black sulfidic metashale and metagraywacke that characterize the upper part of the Dixville give way to a much thicker bedded sequence in which metagraywacke is predominant.

The graywacke member is about 1,000 feet thick. This approximate thickness was interpreted from a north-south structure section between the north end of Hunter Cove and the south margin of the pluton to the north.

SHALE MEMBER

The dominant rock of the shale member of the Quimby Formation is rusty-weathering cyclically interbedded medium-gray to black metashale and subordinate amounts of metagraywacke. Although bedding thicknesses and the proportions of metashale to metagraywacke are variable, in most outcrops 1- to 3-inch beds of metashale alternate with 1-inch beds of metagraywacke. The metashale is vari-

ably carbonaceous slate, phyllite, or schist. Although aluminum silicate minerals are present in the appropriate metamorphic zones, the metashale is somewhat less aluminous than the metashales of younger formations. Sulfide minerals, mostly pyrrhotite or pyrite, are nearly ubiquitous in the metashale, but their abundance is variable. The upper part of the formation in both the Rangeley area and the Brimstone Mountain anticline is particularly sulfide-rich (fig. 3). The beds of metagraywacke, typically an inch thick, range locally in thickness from paper-thin to 5 feet. Some are lenticular, or pinch and swell along strike, but most show little change in thickness where they cross an outcrop. Graded bedding and parallel lamination within beds are common; cross-lamination is rare.

Distinctive beds of calc-silicate rock that are less than an inch to a few inches thick are common in the upper part of the shale member. The calc-silicate rock is a dense, brittle, black, and sulfidic rock with thin lenses and knots of coarsely intergrown quartz, pyrrhotite, and various calc-silicate minerals, such as calcic plagioclase, grossularite, actinolite, diopside, and clinozoisite. The dense black rock is probably a carbonaceous calcareous metasiltstone. It is typically composed of fine-grained calcic plagioclase and smaller amounts of quartz, biotite, chlorite, pyrrhotite, and abundant dustlike particles of carbon(?). Garnet, clinozoisite, and other calc-silicate minerals may be abundant near the coarser-grained knots.

Metagraywacke is more abundant than metashale in two zones in both the Rangeley area and the Brimstone Mountain anticline (fig. 3). Although these zones seem to occupy about the same stratigraphic positions in the respective areas, data are inadequate to permit them to be accurately correlated. In the Rangeley area, metagraywacke of the two zones is in graded beds that range in thickness from 1 inch to about 5 feet. Many beds contain slate chips. Some beds are conglomeratic, containing tabular and elongate fragments of metamorphosed shale, siltstone, quartzite, felsic and mafic volcanic rocks, vein quartz, and chert. These fragments are generally confined to the basal few inches of the thickest beds, where they are oriented parallel to schistosity or to slaty cleavage, and they are set in a matrix of metagraywacke. The metagraywacke is mineralogically and texturally identical with the graywacke member; quartz is subordinate to plagioclase and primary graywacke textures are well preserved. In the Brimstone Mountain anticline, an area of more intense metamorphism than the Rangeley area, the metagraywacke has an equigranular metamorphic texture, but proportions in it of quartz, plagioclase, and micas are the same as for the metagraywacke of the Rangeley area.

A single bed of probable felsic metavolcanic rock about 10 feet thick was found in the upper sulfide-rich zone (fig. 3) in the Rangeley area. It is very light gray, dense, and massive and is composed of about 37 percent quartz, 35 percent plagioclase, 22 percent muscovite, 5 percent biotite, and 1 percent accessory minerals. Viewed in thin section, most quartz and plagioclase are fine grained and equigranular, and the mica is well foliated and evenly distributed. The rock also has widely spaced large anhedral grains of plagioclase and lenticular aggregates of quartz and feldspar that are several times as large as the grains of the groundmass.

The shale member conformably overlies the graywacke member in a gradational zone marked by an upward decrease in the thickness of bedding and in the proportion of metagraywacke to metashale. The contact is placed where the abundance of metagraywacke becomes less than 50 percent and the thickness of bedding decreases to about 1 inch.

The shale member is about 2,000 feet thick. This thickness was interpreted from a structure section that was constructed from data obtained along the east shore of Rangeley Lake.

GREENVALE COVE FORMATION

The Greenvale Cove Formation is named here for exposures of light-colored interlaminated metashale, metasiltstone, and metasandstone found in roadcuts along State Highway 4 and along the northeast shore of Greenvale Cove, the type locality (fig. 2). The lower contact at the type locality is exposed on the lake shore. The upper contact is exposed on the hillside about 2,700 feet horizontally east-northeast of the lower contact. Data for the stratigraphic column of the Greenvale Cove in the Rangeley area (fig. 3) were obtained from the type locality. Data for the column in the Brimstone Mountain anticline were obtained from the areas indicated in figure 2. The separate belts of the Greenvale Cove Formation in the northern and southern parts of the quadrangle are correlated by lithologic similarity and position in the stratigraphic sequence.

The Greenvale Cove Formation is divisible into three zones in both the Rangeley area and the Brimstone Mountain anticline (fig. 3). The lower zone, which forms approximately the lower half of the formation, is composed of light-gray or pale-greenish-gray or brownish-gray metashale interlaminated with about 25–50 percent fine-grained metasandstone. In the Rangeley area, the laminations of metasandstone are typically 0.1–0.3 inch thick and range in thickness from paper thin to about 0.5 inch, whereas in the Brimstone Mountain anticline, laminations of metasandstone tend to be somewhat thicker. Beds as much as 1 foot thick are common in the anticline.

The middle zone is composed largely of interlaminated metasiltstone and fine-grained metasandstone; metashale is less abundant than in the lower zone. In the Brimstone Mountain anticline the rocks are interlaminated light-brownish-gray biotite granofels and pale-greenish-gray, bluish-gray and white calc-silicate rocks that were originally carbonate-cemented clastic quartz-feldspar-rich sediments. In the Rangeley area the clastic rocks of the middle zone are generally less calcareous.

The upper zone is thin and locally absent (fig. 3). It is composed of equal amounts of interlaminated noncalcareous metasandstone and metashale. In the Rangeley area, the metashale of the upper zone is a slightly darker gray and the metasandstone is slightly coarser grained than the metashale and metasandstone of lower parts of the formation. In the Brimstone Mountain anticline these subtle differences are not recognizable, owing to more intense metamorphism.

Most outcrops of the Greenvale Cove Formation are characterized by alternating sharply defined laminations of different composition, which give the rock a strikingly banded appearance. Graded bedding is common, but may be recognizable within only one or two laminations of metasandstone at any one outcrop. Some of the thicker laminations are faintly internally cross-laminated. The metashale is micaceous slate, phyllite, or schist, whereas the metasiltstone and metasandstone are poorly foliated micaceous quartz-plagioclase granofels. Except for a few laminations of metagraywacke near the base of the formation, the metasandstones of the Greenvale Cove are compositionally and texturally more mature than those of the Quimby. At low metamorphic grades the metasandstones of the Greenvale Cove tend to be better sorted, and the ratio of sand-sized clasts to matrix is greater. Modal analyses of typical noncalcareous laminations of metasandstone indicate 45–65 percent quartz, 15–30 percent plagioclase (oligoclase), and 15–30 percent total mica (about 15 percent biotite, and as much as 5 percent chlorite and 12 percent muscovite in the rocks studied). These rocks are compositionally similar to the metasandstones of the overlying Rangeley Formation, but are much richer in quartz than is the metagraywacke of the Quimby Formation.

The mineralogy of the calcareous metasiltstone and metasandstone in the Brimstone Mountain anticline is varied. The light-brownish-gray biotite granofels is composed of about equal amounts of quartz and of calcic plagioclase, abundant but smaller amounts of biotite, and minor amounts of clinozoisite and sphene; microcline is locally abundant. The laminated pale-green, white, and pale-bluish-gray calc-silicate rocks are composed largely of quartz, calcic plagioclase, hornblende, and diopside in variable proportions; sphene, clinozoisite, and garnet are common.

The contact between the Quimby and Greenvale Cove Formation is conformable. Where well exposed the contact can be placed within a few inches. It is marked by an abrupt gradation from carbonaceous sulfidic metashale of uppermost Quimby to lighter gray, less sulfidic, more distinctly laminated rocks of the Greenvale Cove. In the Brimstone Mountain anticline, where the upper sulfidic zone of the Quimby is thin and only locally exposed, the contact is less definite than it is in the Rangeley Lake area.

The contact between the Greenvale Cove Formation and the overlying Rangeley Formation is conformable. Though the sedimentary environment changed abruptly, sedimentation was probably continuous. At the type locality the contact is placed at the base of a graded bed of coarse-grained feldspathic metasandstone, about 3 feet thick, that conforms to bedding in the underlying Greenvale Cove metashale. This bed is overlain by a transition zone about 25 feet thick in which thick beds of metasandstone alternate with much thinner partings of gray metashale. The transition zone is in turn overlain by the main mass of basal metasandstone and metaconglomerate of the Rangeley Formation (Osberg and others, 1968). Southward along the limb of the Brimstone Mountain anticline, increasing thicknesses of metashale intervene between the top of the Greenvale Cove and the thick-bedded coarse clastics of the Rangeley. This intervening metashale is part of the Rangeley Formation. The upper contact of the Greenvale Cove Formation in this area is placed where distinctly laminated rock abruptly gives way to the generally thicker bedded pelitic rocks of the basal part of the Rangeley Formation.

The Greenvale Cove Formation is about 600 feet thick in the Rangeley area and 300–500 feet thick in the Brimstone Mountain anticline. These thicknesses were estimated from structure sections that were drawn through the areas of best exposure. The formation seems to be thinnest near the south boundary of the Rangeley quadrangle.

AGE AND ORIGIN

Approximately 11,500 feet of strata lie between the dated Middle Ordovician rocks of the Dixville Formation (Harwood and Berry, 1967) and the tentatively dated Lower Silurian(?) rocks of the upper part of the Rangeley Formation. This thickness includes about 3,000 feet of Quimby, 500 feet of Greenvale Cove, 4,000 feet of coarse clastics in the lower part of the Rangeley Formation (the Rangeley Conglomerate of Smith, 1923), and 4,000 feet of conglomeratic metashales of the middle part of the Rangeley Formation. The Early Silurian(?) age of the Rangeley Formation is based on the tentative correlation by E. L. Boudette and D. S. Harwood of fossiliferous quartz conglomerate

and nearby polymictic conglomerate in the Kennebago Lake quadrangle with the Rangeley Formation a few miles to the south (U.S. Geological Survey, 1965, p. A74). The fossils were identified by A. J. Boucot as late Llandoverian, C_4–C_5. They occur in beds of metamorphosed quartz conglomerate that are interbedded with metasandstone and metashale. These rocks are probably equivalent to the interbedded locally calcareous quartz metaconglomerate, metasandstone, and metashale of the uppermost 1,000 feet of the Rangeley Formation in the Rangeley quadrangle. In turn, the polymictic conglomerate, which actually underlies the fossiliferous rocks, is correlated with the polymictic metaconglomerate of the lowermost 4,000 feet of the Rangeley Formation farther south. The author believes, therefore, that only the uppermost part of the Rangeley Formation is late Llandoverian (C_4–C_5); the lower and middle parts may well be early or middle Llandoverian.

Because of the great thickness of strata between dated rocks, the Ordovician-Silurian time boundary is placed tentatively at the most conspicuous lithologic change—namely, the upper contact of the Greenvale Cove Formation. The Quimby and Greenvale Cove Formations are thus considered to be Late Ordovician(?). Further search for fossils is recommended in the exposures of uppermost Quimby and Greenvale Cove at the north border of the Rangeley quadrangle, about 5 miles northeast of Rangeley (fig. 2). Low-grade slates of these formations are exposed in that area along Redington Stream, at Flagg Dam on the south branch of the Dead River, and along logging roads on the north side of the valley. (See U.S. Geol. Survey topographic map of Rangeley quadrangle, revised 1949.)

The Quimby Formation is a turbidite-shale sequence that was deposited in a euxinic marine environment. The shaly rocks are gray and variably carbonaceous and sulfidic; the interbedded coarser grained clastic rocks have characteristics that are commonly attributed to turbidity flow deposits, such as poor sorting of immature clastic materials and graded bedding. Turbidity flows bearing large quantities of coarse clastics were frequent when the lower graywacke member was deposited; they were less frequent and of generally smaller magnitude when the upper shale member was deposited. The sandy and conglomeratic clastics were derived from a sedimentary-volcanic terrane, but the whereabouts of this terrane is unknown.

The Greenvale Cove Formation was probably deposited in a shallower marine environment than the Quimby; circulation improved and traction currents became more important. The rocks are generally noncarbonaceous, nonsulfidic, distinctly laminated, locally cross-laminated and are composed of sediments that are better sorted and more

mature than those of the Quimby Formation. The fact that part of the formation becomes more calcareous toward the south suggests that the source area was to the north. Perhaps the Somerset geanticline (Cady, 1967, p. 64) was beginning to emerge when the Greenvale Cove Formation was deposited.

In the northern part of the Rangeley quadrangle, the quiet marine sedimentary environment of the Greenvale Cove Formation ended abruptly with a great influx of coarse clastic sediments. These sediments, now the lower part of the Rangeley Formation, were shed from the Somerset geanticline as it was uplifted and deeply eroded during the Taconic disturbance. Toward the south, coarse clastics of the Rangeley become less abundant and finer grained; they tongue into a thick body of gray Rangeley metashale. At the places where this metashale overlies the Greenvale Cove Formation, the transition represents a subtle change in sedimentary environment. Traction currents gave way to occasional turbidity flows; precipitation of carbonate mineral stopped, and pelitic sediments were deposited in a more poorly aerated muddy environment.

Before the Taconic disturbance, the Quimby and Greenvale Cove Formations or their equivalents may have been widespread in New England and southeastern Quebec, but if they were, they were removed throughout much of the region by the erosion that accompanied the disturbance. Probable age equivalents of the Quimby and Greenvale Cove Formations are (1) the Upper Ordovician (?) Sherbrooke Formation, exposed in Quebec, about 80 miles northwest of Rangeley (St. Julien, 1965) and (2) part of the Middle Ordovician to Lower Silurian Carys Mills Formation, exposed in northern Maine about 180–200 miles northeast of Rangeley (Pavlides and Berry, 1966; Pavlides, 1966). The Carys Mills Formation and the Quimby and Greenvale Cove Formations were probably deposited in the same sedimentary trough. This trough apparently continued to subside during the Taconic disturbance and received sediments from the adjacent rising areas (Pavlides and others, 1968; Osberg and others, 1968). Whether the Sherbrooke Formation and the rocks of similar age in Maine once joined across the Somerset and Stoke Mountain geanticlines (Cady, 1967) cannot be interpreted from present information.

REFERENCES CITED

Billings, M. P., 1956, Bedrock geology, Pt. 2 *of* The geology of New Hampshire: Concord, New Hampshire State Plan. and Devel. Comm., 203 p.

Cady, W. M., 1967, Geosynclinal setting of the Appalachian Mountains in southeastern Quebec and northwestern New England, *in* Appalachian tectonics: Royal Soc. Canada Spec. Pub. 10, p. 57–67.

Green, J. C., 1964, Stratigraphy and structure of the Boundary Mountain anticlinorium in the Errol quadrangle, New Hampshire-Maine: Geol. Soc. America Spec. Paper 77, 78 p.

Harwood, D. S., and Berry, W. B. N., 1967, Fossiliferous lower Paleozoic rocks in the Cupsuptic quadrangle, west-central Maine, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575–D, p. D16–D23.

Osberg, P. H., Moench, R. H., and Warner, Jeffrey, 1968, Stratigraphy of the Merrimack synclinorium in west-central Maine, *in* Studies in Appalachian Geology—Northern and Maritime (Billings Volume): New York, John Wiley and Sons, p. 241–254.

Pavlides, Louis, 1966, Meduxnekeag Group and Sprague ville Formation of Aroostook County, Northeast Maine, *in* Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1965: U.S. Geol. Survey Bull. 1244–A, p. A52–A60.

Pavlides, Louis, and Berry, W. B. N., 1966, Graptolite-bearing Silurian rocks of the Houlton-Smyrna Mills area, Aroostook County, Maine, *in* Geological Survey research 1966: U.S. Geol. Survey Prof. Paper 550–B, p. B51–B61.

Pavlides, Louis, Boucot, A. J., and Skidmore, W. B., 1968, Stratigraphic evidence for the Taconic orogeny in the Appalachians, *in* Studies in Appalachian Geology—Northern and Maritime (Billings Volume): New York, John Wiley and Sons, p. 61–82.

St. Julien, Pierre, 1965, [Geologic map] Orford-Sherbrooke area, Richmond, Sherbrooke, Shefford, Brome, Stanstead, and Compton Counties [Quebec]: Quebec Dept. Nat. Resources, Mineral Deposits Services Map 1619.

Smith, Edward S. C., 1923, The Rangeley conglomerate [Maine]: Am. Jour. Sci., 5th ser., v. 5, p. 147–154.

U.S. Geological Survey, 1965, Geological Survey research 1965: U.S. Geol. Survey Prof. Paper 525–A, 376 p.

Williams, Howel, Turner, F. J., and Gilbert, C. M., 1954, Petrography—an introduction to the study of rocks in thin sections: San Francisco, W. H. Freeman and Co., 406 p.

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