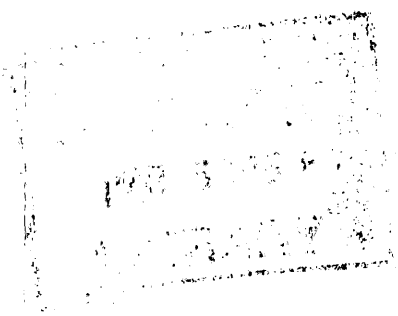
Changes in Nomenclature of Upper Precambrian to Lower Paleozoic(?) Formations in the Natick Quadrangle, Eastern Massachusetts, and Their Tentative Correlations With Rocks in Rhode Island and Connecticut

---

GEOLOGICAL SURVEY BULLETIN 1395-E

Prepared in cooperation with the Commonwealth of Massachusetts Department of Public Works

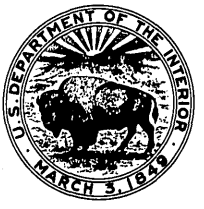


Changes in Nomenclature of Upper Precambrian to Lower Paleozoic(?) Formations in the Natick Quadrangle, Eastern Massachusetts, and Their Tentative Correlations With Rocks in Rhode Island and Connecticut

By ARTHUR E. NELSON

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1395-E



Prepared in cooperation with the Commonwealth of Massachusetts Department of Public Works

Three formations are named and defined in a 3,500-meter section of upper Precambrian to lower Paleozic(?) sedimentary and volcanic rocks in eastern Massachusetts

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 74-600146

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 — Price 35 cents (paper cover)
Stock Number 2401-02549

CONTENTS

ILLUSTRATIONS

TABLE

CONTRIBUTIONS TO STRATIGRAPHY

CHANGES IN NOMENCLATURE OF UPPER PRECAMBRIAN TO LOWER PALEOZOIC(?) FORMATIONS IN THE NATICK QUADRANGLE, EASTERN MASSACHUSETTS, AND THEIR TENTATIVE CORRELATIONS WITH ROCKS IN RHODE ISLAND AND CONNECTICUT

By ARTHUR E. NELSON

ABSTRACT

Approximately 3,500 meters of upper Precambrian to lower Paleozoic(?) metamorphosed sedimentary and volcanic rocks are exposed in the northwestern half of the Natick quadrangle. The lower part of this sequence is intruded by Precambrian granodiorite; the upper part is faulted out.

As a result of the detailed mapping, it is possible to name and define several formations in this rock sequence: a unit of upper Precambrian biotite gneiss, schist, quartzite, and amphibolite is named the Rice Gneiss; a unit of mafic and felsic volcanic rocks is named the Cherry Brook Formation; a unit of fine-grained felsic and mafic gneiss and schist is named the Claypit Hill Formation; and the previously named Kendall Green Slate is renamed the Kendal Green Formation.

The upper Precambrian to lower Paleozoic(?) rocks are tentatively correlated with formation of the Blackstone Series in Rhode Island and with the Plainfield, Quinebaug, and Mamacoke Formations in Connecticut.

INTRODUCTION

This report presents changes in stratigraphic nomenclature of a succession of upper Precambrian to lower Paleozoic(?) rocks in the Natick quadrangle, Massachusetts. Three stratigraphic units are formally named, one previously named unit is renamed, and possible correlations with rocks in Rhode Island and Connecticut are given. Stratigraphic studies undertaken in the Natick quad-

rangle (fig. 1) are part of a larger program of geologic mapping in Massachusetts by the U.S. Geological Survey, in cooperation

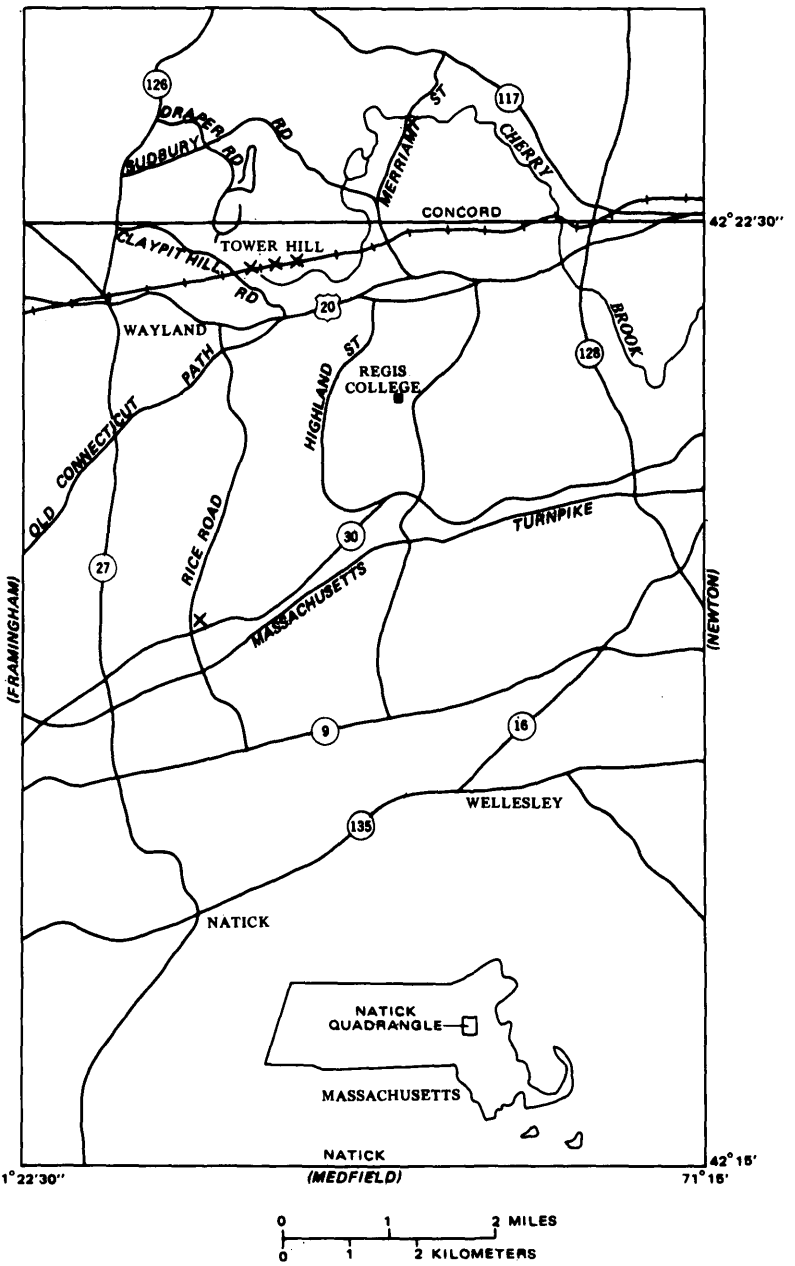


FIGURE 1.—Map of the Natick and part of the Concord quadrangles. × indicates type locality.

with the Department of Public Works of the Commonwealth of Massachusetts.

The geologic section in the Natick quadrangle consists of sedimentary and volcanic rocks of Precambrian to Carboniferous age (table 1). Figure 2 is a generalized geologic map. The prominent northeast-trending Basin fault separates Silurian to Carboniferous rocks of the Boston basin on the southeast from older rocks on the northwest. The older rocks are distinctly different in lithology and have been regionally metamorphosed to the almandine amphibolite facies. A batholith, stocks, and dikes of granodioritic to gabbroic composition have intruded parts of the section northwest of the Basin fault. This report discusses the nomenclature and stratigraphy of the upper Precambrian to lower Paleozoic(?) rocks.

Much of the quadrangle is covered by a veneer of glacial deposits (Nelson, 1974) that conceals contacts between formations. Therefore, thicknesses of or contact relations between stratigraphic units are not precisely known. However, the interpretations pre-

TABLE 1.—*Stratigraphic succession and thickness of sedimentary and volcanic rock units presently recognized in the Natick quadrangle*

	Estimated thickness (meters)
Upper Silurian to Carboniferous:	
Cambridge Slate	370
Brighton Melaphyre	1,070
Roxbury Conglomerate	1,130
Mattapan Volcanic Complex:	
Laharic member	335
Andesitic volcanic member	850
Siliceous pyroclastic member	760
BREAK IN SEQUENCE	
Precambrian Z to lower Paleozoic(?):	
Amphibolite	460
BREAK IN SEQUENCE	
Claypit Hill Formation[1]	460–610
UNCONFORMITY	
Cherry Brook Formation[1]:	
Amphibolite	610
Felsic tuff	290
Precambrian Z(?):	
Kendal Green Formation[2]	215
Precambrian Z:	
Westboro Quartzite	980
Rice Gneiss[1]	760
Total thickness in quadrangle	8,440

[1] New name.
[2] Renamed.

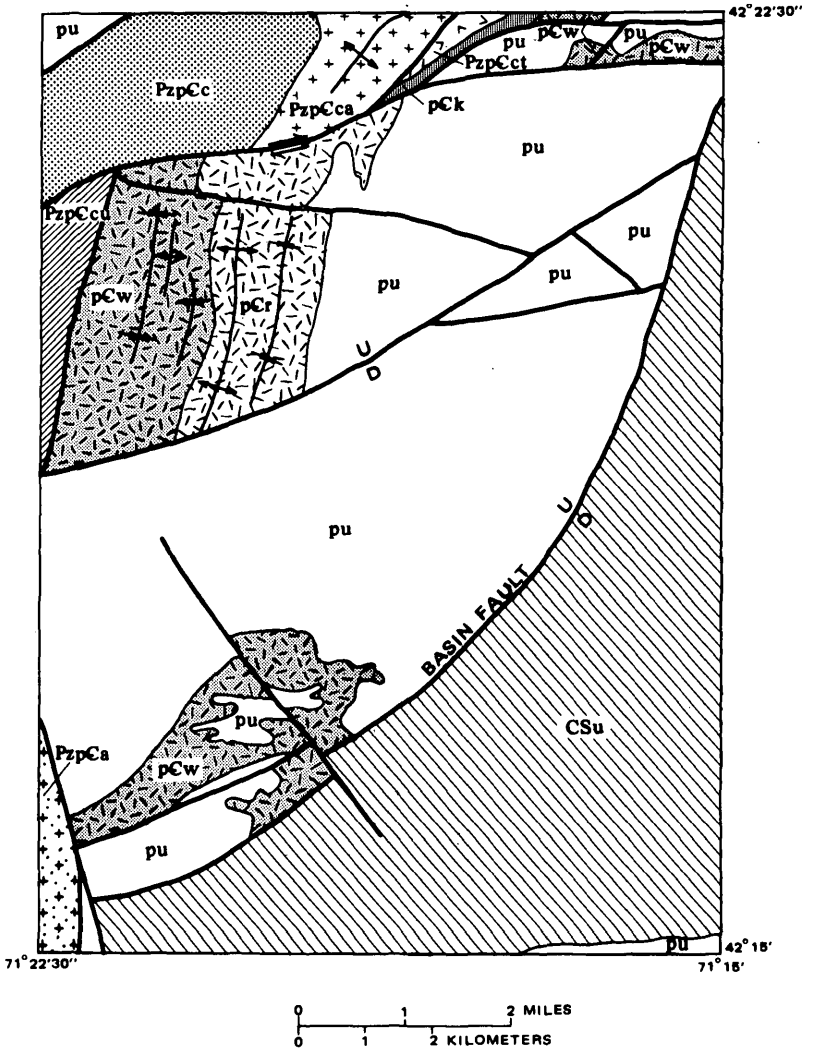


FIGURE 2.—Generalized geologic map of the Natick quadrangle.

sented here appear to be in general agreement with those established elsewhere in eastern Massachusetts (Norman Cuppels, oral commun., 1968), in Connecticut (Goldsmith, 1966), and in Rhode Island (Quinn, 1971).

STRATIFIED ROCKS

A series of nonfossiliferous formations that apparently are a conformable sequence is present in the northern and western

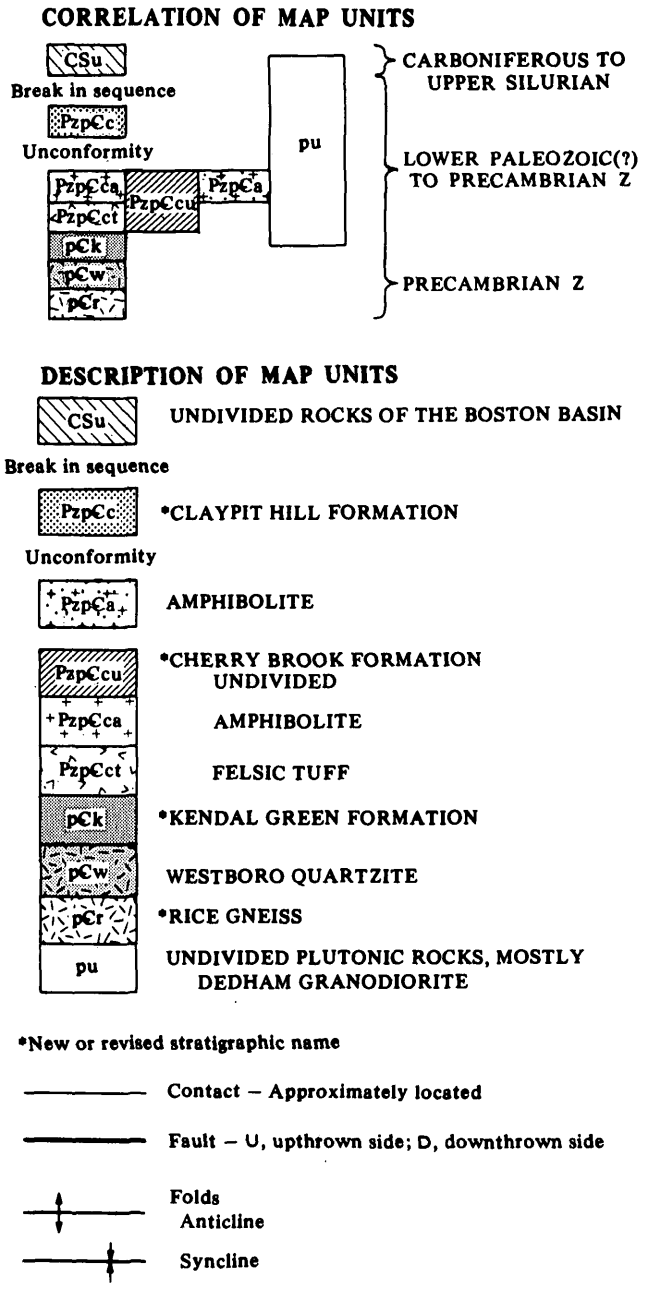


FIGURE 2.—Continued.

part of the quadrangle. All or parts of these rock units are also exposed in quadrangles to the north, northeast, and west. In order

of decreasing age, these rocks are the Rice Gneiss, Westboro Quartzite, Kendal Green Formation, and Cherry Brook Formation. Unconformably overlying the Cherry Brook is the Claypit Hill Formation.

RICE GNEISS

The oldest rocks exposed in the quadrangle are a sequence of intercalated variably textured and layered biotite gneiss, schist, and quartzite. These rocks are here named the Rice Gneiss after Rice Road, along which much of the formation is exposed (figs. 1, 2). The type locality is the exposure just northeast of the intersection of Massachusetts Rte. 30 and Rice Road in the northwestern part of the Natick quadrangle. Other exposures of the formation are in the Weston town forest about 0.4 mile (0.64 km) west of Regis College and along the west side of the north-trending ridge that is half a mile east of Rice Road.

The formation reaches a maximum thickness of 760 m and is mostly thin bedded, although beds and layers range from 0.5 cm to 1 m in thickness. The rocks are foliated and, where observed, the foliation is parallel to the lithologic layering. The formation generally strikes north and is folded about north-trending fold axes. It is apparently conformably overlain to the west by the Westboro Quartzite, and the lower part of the gneiss unit is intruded by the Dedham Granodiorite.

Most of the Rice Gneiss is a medium- to dark-gray, fine- to medium-grained, equigranular to inequigranular plagioclase-quartz-biotite gneiss that is interlayered with equigranular to inequigranular and irregularly layered biotite-plagioclase-quartz gneiss and schist, quartz-biotite-microcline-muscovite schist, and some thin beds of quartzite and feldspathic quartzite. Locally, the Rice Gneiss is garnetiferous, is intruded by small granitic and pegmatitic veins, and, in places, contains irregular pods and veinlets of silexite. Except for the quartzites, which undoubtedly were originally accumulations of almost pure quartz (beach) sand, most of the formation resulted from metamorphism of tuffaceous materials that were variably mixed with quartz sand.

The Rice Gneiss is not known to correlate with any other rock unit in Massachusetts, and as fossils have not been found in it, its age is not known for certain. However, the formation is believed to be late Precambrian (Precambrian Z) in age because it is intruded by the Dedham Granodiorite from which Zartman (written commun., 1971) obtained a zircon isotopic age of 630±20 m.y. from a sample collected in the Natick quadrangle. Fairbairn,

Moorbath, Ramo, Pinson, and Hurley (1965) also consider the Dedham Granodiorite exposed at nearby Dedham to be of Late Precambrian age.

WESTBORO QUARTZITE

Westboro Quartzite was originally named by Perry and Emerson (1903, p. 155) for exposures consisting mostly of quartzite in Westboro, Mass. In the Natick quadrangle, the Westboro is predominantly quartzite and feldspathic quartzite variably interlayered with mica-quartz schist and some amphibolite. The formation is exposed in several fault blocks across the northern part of the quadrangle and in a large area in the southwestern part (fig. 2); in addition, many small inclusions of these rocks are present in the younger Dedham Granodiorite.

The Westboro has a maximum thickness of about 980 m in the Natick quadrangle. It strikes north in the west-central part of the quadrangle where it is principally exposed and, like the underlying Rice Gneiss, is folded around north-trending axes. Although contacts with older and younger rocks were not observed, the Westboro appears to be conformably overlain by the Kendal Green Formation in the northeastern part of the quadrangle and in the adjoining Concord quadrangle.

Three distinct units make up the Westboro in the Natick quadrangle, but because contacts are concealed by glacial deposits the units could not be mapped. The lower unit is a light-gray massively bedded almost pure quartzite with minor interbedded biotite gneiss. The massive character of the rock at some exposures makes it difficult to recognize bedding, but locally beds are in excess of 5 m thick.

An assemblage of dark- to medium-gray fine-grained biotite and hornblende gneisses and schists, relatively pure quartzite, feldspathic quartzite, and amphibolite make up the middle unit of the Westboro. These rocks are interlayered in all proportions, and the beds vary widely in thickness, but, with the exception of a 5.5-m bed, most beds are between 3 cm and 1.5 m thick. Biotite gneiss and schist are the predominant rock types in the lower part of this unit; amphibolite is the least common type.

The upper unit is a light-gray thick- to massively bedded quartzite in which bedding is difficult to observe. A few thin intercalations of biotite gneiss are found near its base.

The Westboro probably formed from the accumulation of varying amounts of volcanic materials (tuff) and quartz (beach) sand in a depositional basin. At times, little if any volcanic debris

was deposited, and relatively thick deposits of quartz sand were laid down, which eventually resulted in the thick units of quartzite. At other times, volcanic detritus was mixed with the quartz sand, which resulted in feldspathic quartzite, gneiss, and schist. The amphibolites were originally mafic tuffs or basaltic lava flows.

The Westboro is nonfossiliferous. Like the Rice Gneiss, it has been intruded by Precambrian Dedham Granodiorite and is presumed to be of late Precambrian (Precambrian Z) age.

KENDAL GREEN FORMATION

The name Kendal Green Formation is herein changed from the original usage of Hobbs (1899, p. 110), who called the same rocks the Kendall Green Slate. The Kendal Green is not a slate; it is primarily a very fine grained, light-tan, thinly laminated, felsic tuff that is interlayered with dark-greenish-gray fine-grained thinly laminated tuff and some discontinuous layers of quartzite. In addition, the spelling is changed to conform to that of the geographic name, Kendal Green. The Kendal Green has an estimated maximum thickness of 215 m in the Natick quadrangle. The age of the Kendal Green, although uncertain, is probably late Precambrian (Precambrian Z).

The relationship between the Westboro Quartzite and Kendal Green is critical to the stratigraphy of eastern Massachusetts. Farther to the northeast, Kenneth Bell (written commun., 1973) indicates that mafic volcanic rocks similar to the upper part of the Cherry Brook Formation rest conformably on the Westboro Quartzite and, furthermore, that rocks resembling the siliceous tuff of the Kendal Green overlie the mafic volcanics. In the Natick quadrangle, however, the Kendal Green appears to overlie the Westboro; unfortunately, exposures between the two formations are too sparse to resolve the problem satisfactorily. One can assume that either a fault or an unconformity separates the two formations. In the Natick quadrangle area, however, field relations do not support evidence for a fault, as neither gouge nor breccia zones have been observed and neither formation is truncated. Furthermore, bedding within the two formations is essentially parallel. Therefore, it is believed the Kendal Green rests conformably on the Westboro and that a pulse of felsic volcanism produced, in the Natick area, the siliceous tuff prior to the deposition of the mafic volcanic rocks.

CHERRY BROOK FORMATION

Overlying the Kendal Green Formation is a thick assemblage of

mostly amphibolite with some felsic volcanic rocks at the base. This assemblage is here named the Cherry Brook Formation, after Cherry Brook along which a large part of the formation is present. The type locality is approximately 1 mile (1.6 km) north of the Natick quadrangle in the adjoining Concord quadrangle, where several exposures are located southeast of the Merriam Street crossing of Cherry Brook. Other exposures are present along Merriam Street, on some small hills east of Merriam Street, and north of the railroad in the Natick quadrangle. Felsic volcanic rocks are present about 0.6 mile (0.96 km) east of Merriam Street along the railroad in the Natick quadrangle.

The Cherry Brook Formation is as much as 900 m thick in the Natick quadrangle and more than 1,200 m thick in the adjoining Concord quadrangle (Nelson, unpub. data). The rocks are folded, but the axes trend northeast rather than north as in the Rice Gneiss and Westboro. Bedding is typically obscure and variable, ranging from several centimeters to 1 m or more thick. These rocks have been metamorphosed to amphibolite facies and, where determined, the schistosity is parallel to bedding.

In the Natick quadrangle, the lower part of the formation is a light- to pinkish-gray, fine- to medium-grained, massive felsic crystal tuff with a few thin beds of dark medium-grained biotite-quartz-feldspar schist; this part is as much as 290 m thick.

Amphibolite and intercalated biotite schist and quartzite constitute the upper part of the Cherry Brook. The predominant rock type is amphibolite; it is equigranular to inequigranular, fine to coarse grained, thin to thick layered, and locally striped with thin alternating discontinuous felsic and mafic bands. In places, the rocks are massive and typically amygdaloidal. Some exposures show a vague suggestion of pillow structures.

In the Natick quadrangle, the Cherry Brook Formation is a thick sequence of metamorphosed volcanic tuffs and flows. Felsic tuffs formed the lower part of the formation; later, vast accumulations of basaltic to andesitic tuffs and flows were deposited to form the upper part of the formation.

The age of the Cherry Brook is uncertain. Previously, these rocks were considered to be part of the Marlboro Formation of Precambrian(?) age (Emerson, 1917, p. 25). However, detailed mapping in the Natick (Nelson, 1974) and Framingham (Nelson, unpub. data) quadrangles shows that these rocks do not correlate with the Marlboro Formation exposed at the type locality in Marlboro, Mass. The Cherry Brook overlies the Kendal Green Forma-

tion and is believed to be late Precambrian to early Paleozoic(?) in age.

CLAYPIT HILL FORMATION

Unconformably overlying the Cherry Brook Formation is an assemblage of hornblende- and biotite-bearing gneisses interleaved with felsic gneiss and amphibolite. These rocks are here named the Claypit Hill Formation for exposures near Claypit Hill Road. The type locality includes exposures along the railroad between 0.1 and 0.4 mile (0.16–0.64 km) east of Claypit Hill Road. Other exposures of this rock can be seen along an unnamed road, about 0.25 mile (0.4 km) north of the quadrangle, that runs east from Draper Road in the Concord quadrangle.

A thick cover of glacial deposits (Nelson, 1974) conceals most of the formation, and data on its thickness and structure are sparse. Nevertheless, it is estimated to be between 460 and 610 m thick. The upper part is truncated by a fault in the Natick quadrangle. Where observed, the bedding is parallel to schistosity and ranges from about 8 cm to 0.5 m in thickness.

Most of the Claypit Hill is a dark-greenish-gray, fine-grained hornblende-plagioclase-quartz-epidote gneiss. It is interlayered with medium-gray fine- to medium-grained almost equigranular biotite-plagioclase-quartz-muscovite gneiss that locally contains garnet and rarely sillimanite; medium- to dark-gray fine-grained hornblende-biotite-plagioclase-quartz gneiss; medium- to dark-gray equigranular biotite-plagioclase-quartz-microcline gneiss; and minor thin beds of dark-gray fine- to medium-grained amphibolite. In places, epidote, chlorite, and sericite are abundant. It is possible that other less resistant rock types are concealed by surficial deposits, but none have been observed to date.

The age of the Claypit Hill is uncertain, however, as the formation apparently unconformably overlies the Cherry Brook, which is believed to be of late Precambrian to early Paleozoic(?) age; the Claypit Hill is tentatively assigned a late Precambrian to early Paleozoic(?) age.

CORRELATIONS OF FORMATIONS IN EASTERN MASSACHUSETTS WITH ROCK UNITS IN RHODE ISLAND AND CONNECTICUT

Upper Precambrian to lower Paleozoic(?) rocks in the Natick quadrangle are believed to correlate with some formations in Rhode Island and Connecticut that occupy the same relative stratigraphic position and have similar thicknesses and lithologic characteristics (fig. 3). The stratigraphic sections that are be-

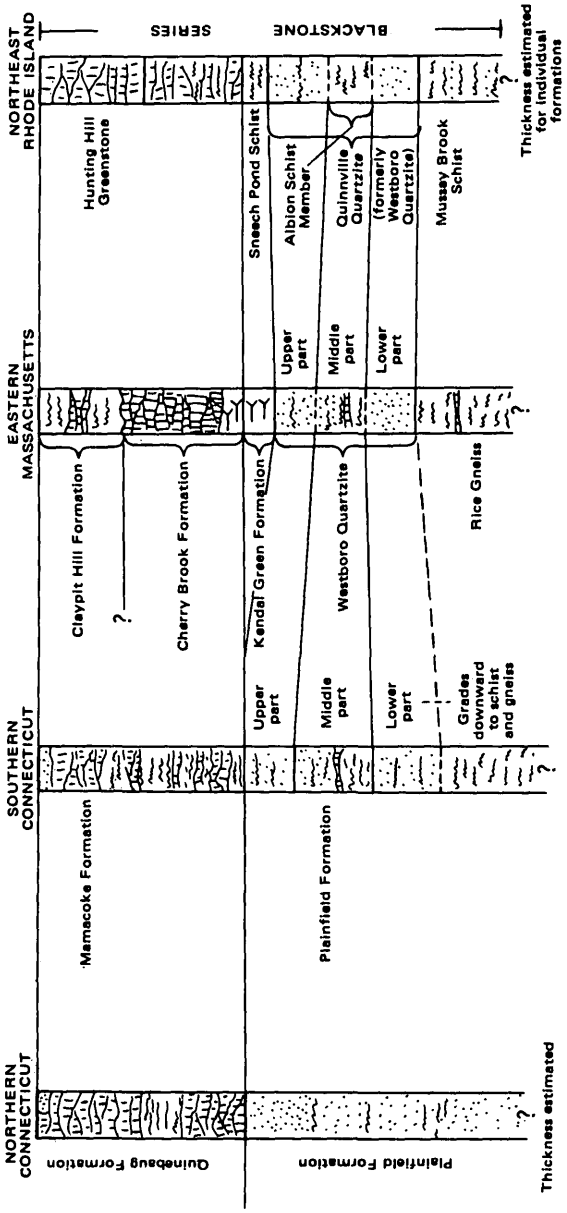


FIGURE 3.—Generalized sections and tentative correlations of some rocks in Connecticut, Massachusetts, and Rhode Island.

lieved to correlate with one another are: in eastern Massachusetts, a section about 3,465 m thick that includes the Rice Gneiss, Westboro Quartzite, and Kendal Green, Cherry Brook, and Claypit Hill Formations; in northeast Rhode Island, the Blackstone Series, which is about 3,300 m thick (Quinn, 1953, p. 266) and which includes the Mussey Brook Schist, Quinnville Quartzite (formerly Westboro Quartzite), Sneech Pond Schist, and Hunting Hill Greenstone (Quinn and others, 1948, p. 10–13; Quinn, 1971, p. 12–13); in southern Connecticut, the Plainfield and Mamacoke Formations that are about 3,360 m thick (Goldsmith, 1966, p. J3–J7); in northern Connecticut, the Plainfield and Quinebaug Formations (Dixon, 1968) of unknown thickness.

The Rice Gneiss is believed to correlate with the Mussey Brook Schist of Rhode Island (Quinn and others, 1948) and with part of the lower part of the Plainfield Formation of Connecticut (Goldsmith, 1966, p. J7). In Rhode Island the Mussey Brook Schist, made up of rocks (mica schist, quartz-feldspar gneiss, quartzite, and some minor lenses of marble) somewhat similar to the Rice Gneiss, is estimated to be about 985 m thick (Quinn and others, 1948, geologic map). The Mussey Brook underlies the Quinnville Quartzite, formerly called the Westboro Quartzite (Quinn, 1971, p. 8). In Connecticut, the lower part of the Plainfield Formation is made up of a thick sequence of white quartzite that grades downward into a thick section of micaceous schist, gneiss, and feldspathic quartzite (Goldsmith, 1966, p. J7). The description of these underlying rocks suggests they are similar to the Rice Gneiss; in addition, they occupy the same relative stratigraphic position.

The Westboro Quartzite in eastern Massachusetts probably correlates with the Quinnville Quartzite in Rhode Island and with most of the Plainfield Formation in Connecticut (Goldsmith, 1966, p. J6–J7; Dixon, 1968). As previously mentioned, the Westboro Quartzite is informally divided into lower, middle, and upper parts in the Natick quadrangle. In Rhode Island, the Quinnville Quartzite consists of quartzite beds above and below the Albion Schist Member (Quinn and others, 1948, p. 12), which is principally a fine-grained quartz-mica schist. The lower and upper parts of the Westboro Quartzite in eastern Massachusetts most probably correlate with the quartzite beds below and above the Albion Schist Member of the Quinnville Quartzite in Rhode Island; the middle part of the Westboro in Massachusetts probably correlates with the Albion Schist Member in Rhode Island.

As much as 980 m of the Westboro Quartzite is present in the

Natick quadrangle, and Quinn, Ray, and Seymour (1948, p. 11) report the Westboro ranges from about 330 to 980 m thick in the Pawtucket quadrangle, Rhode Island.

Correlation of the Westboro Quartzite with the Quinnville is substantiated by Emerson and Perry (1907, p. 10–11), who early in the century traced rocks (Westboro Quartzite) at Westboro, Mass., southward to Rhode Island, where they form part of the Blackstone Series.

In southern Connecticut, the Plainfield Formation can be divided into three parts (Goldsmith, 1966, p. J6–J7) : the lower part consists of quartzite beds that grade downward into micaceous gneiss and schist; the middle part is made up of biotite-quartz-feldspar gneiss, calcsilicate gneiss, amphibolite, schist, and some thin beds of quartzite; the upper part is principally quartzite with some minor intercalations of mica gneiss and schist. All three parts of the Plainfield, with the exception of those gneisses and schists below the thick sequence of quartzite in the lower part, most probably correlate with the corresponding parts of the Westboro Quartzite in Massachusetts. In addition, Lundgren (1966, p. 33) reports that the Plainfield Formation in southern Connecticut can be traced eastward to Rhode Island where equivalent rocks are mapped as part of the Blackstone Series (Westboro Quartzite of Lundgren, 1966).

The Kendal Green Formation, which apparently overlies the Westboro in eastern Massachusetts, may represent a facies change from Sneech Pond Schist in Rhode Island, but its counterpart in southern Connecticut is not known. The Kendal Green is predominantly a very fine grained thinly laminated ash-fall tuff that includes light-tan to gray felsic tuff and intercalated thinly laminated dark-greenish-gray tuff. The Sneech Pond Schist is principally a fine-grained quartz-mica schist of either green or gray color. Although these two formations contain different lithologies, they may be time equivalents.

The Cherry Brook Formation overlies the Kendal Green Formation in the Natick quadrangle; it is an assemblage of mafic to intermediate volcanic flows and volcaniclastic deposits that are intercalated with some minor schists and gneisses. This volcanic sequence together with the overlying gneisses and amphibolites of the Claypit Hill Formation probably correlates with a somewhat similar volcanic sequence in Rhode Island called the Hunting Hill Greenstone. The Hunting Hill, which is the upper part of the Blackstone Series, contains several types of metamorphosed

basaltic rocks that have been altered to greenstone, some of which are massive and some schistose.

Parts of the Mamacoke in southern Connecticut (Goldsmith, 1966, p. J5 and J6) and the Quinebaug Formation in northern Connecticut (Dixon, 1968) are believed to be time equivalents of the Cherry Brook and Claypit Hill Formation in eastern Massachusetts. The Mamacoke, which overlies the Plainfield in southern Connecticut, contains a variety of rocks ranging from amphibolite to dark equigranular biotite-plagioclase gneiss and gray biotite-quartz-feldspar gneiss. Its stratigraphic position is the same as the combined Cherry Brook and Claypit Hill, but the overall lithologic types do not closely resemble the Massachusetts rocks although they may represent facies changes.

The Quinebaug Formation in northern Connecticut occupies the same stratigraphic position as the Cherry Brook and Claypit Hill Formations and, in addition, consists of a similar heterogeneous assemblage of volcanic rocks (Dixon, 1968).

Because the ages of some formations are in doubt, the correlations presented above are necessarily tentative. In eastern Massachusetts some of the rocks undoubtedly are Precambrian in age, and others may be as young as Ordovician. In Rhode Island, although the age of the rocks is somewhat uncertain, the Blackstone Series is considered to be Precambrian(?) in age (Quinn and others. 1948, p. 9: Quinn, 1971, p. 11). Direct evidence for the age of the Plainfield Formation of Connecticut is lacking; it is considered to be of Cambrian and Ordovician age (Goldsmith and Dixon, 1968, p. F–01 or Cambrian(?) age (Harwood and Goldsmith, 1971); in southern Connecticut Lundgren (1966, p. 33) correlated the Plainfield with a part of the Blackstone Series of Precambrian(?) age.

REFERENCES CITED

Dixon, H. R., 1968, Bedrock geologic map of the Danielson quadrangle, Windham County, Connecticut: U.S. Geol. Survey Geol. Quad. Map GQ–696.

Emerson, B. K., 1917, Geology of Massachusetts and Rhode Island: U.S. Geol. Survey Bull. 597, 289 p.

Emerson, B. K., and Perry, J. H., 1907, The green schists and associated granites and porphyries of Rhode Island: U.S. Geol. Survey Bull. 311, 74 p.

Fairbairn, H. W., Moorbath, S., Ramo, A. O., Pinson, W. H., Jr., and Hurley, P. M., 1965, Rb-Sr age of granitic rocks of southeastern Massachusetts and the age of the Lower Cambrian at Hoppin Hill, *in* Variations in isotopic abundances of strontium, calcium, argon and related

subjects: U.S. Atomic Energy Comm., 13th Ann. Prog. Rept. for 1965, Massachusetts Inst. Technology, Department of Geology and Geophysics, NYO–3943, Contract At(30–1)–1381, p. 3–10.

Goldsmith, Richard, 1966, Stratigraphic names in the New London area, Connecticut, *in* Contributions to stratigraphy, 1965: U.S. Geol. Survey Bull. 1224–J, p. J1–J9.

Goldsmith, Richard, and Dixon, H. R., 1968, Bedrock geology of eastern Connecticut, *in* Guidebook for fieldtrips in Connecticut, New England Intercollegiate Geol. Conf., 60th ann. mtg., New Haven, Conn., 1968: Connecticut Geol. and Nat. History Survey Guidebook 2, sec. F–O, 9 p.

Harwood, D. S., and Goldsmith, Richard, 1971, Bedrock geologic map of the Oneco quadrangle, Connecticut-Rhode Island: U.S. Geol. Survey Geol. Quad. Map GQ–930.

Hobbs, W. E., 1899, Some new fossils from eastern Massachusetts: The Am. Geologist, v. 23, p. 109–115.

Lundgren, Lawrence, Jr., 1966, The bedrock geology of the Hamburg quadrangle: Connecticut Geol. and Nat. History Survey Quad. Rept. 19, 41 p.

Nelson, A. E., in press, Surficial geologic map of the Natick quadrangle, Middlesex and Norfolk Counties, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ–1151.

Perry, J. H., and Emerson, B. K., 1903, The geology of Worcester, Massachusetts: Worcester Nat. History Soc., Worcester, Mass., 166 p.

Quinn, A. W., 1953, Bedrock geology of Rhode Island: New York Acad. Sci. Trans., ser. 2, v. 15, no. 8, p. 264–269.

——— 1971, Bedrock geology of Rhode Island: U.S. Geol. Survey Bull. 1295, 68 p.

Quinn, A. W., Ray, R. G., and Seymour, W. L., 1948, Bedrock geology of the Pawtucket quadrangle, Rhode Island and Massachusetts, part 1 of Quinn, A. W., Ray, R. G., Seymour, W. L., Chute, N. E., and Allen, W. B., The geology and ground-water resources of the Pawtucket quadrangle, Rhode Island: Rhode Island Port and Indus. Devel. Comm. Geol. Bull. 3, p. 9–27.

* U.S. GOVERNMENT PRINTING OFFICE: 1974 O—585–466/9