



INTRODUCTION

The Morristown quadrangle is located in north-central New Jersey, in a mixed commercial, industrial and residential setting. The quadrangle is mainly in the Whippany River Watershed and this stream flows eastward as it drains the central part of the area. The southeast part of the map area is drained by the south-flowing Passaic River. The north and east parts of the area include Lee Meadows, Black Meadows and Troy Meadows. These natural wetlands are underlain by the Bontion Formation of Mesozoic age and are capped by sediments of Quaternary and Recent age (Stanford, 2006).

The quadrangle straddles the boundary between the New Jersey Highlands and the Piedmont Provinces but is predominantly in the latter. Bedrock of Mesoproterozoic age in the Highlands underlies the northwest part of the area, and the rest is underlain by Mesozoic-age rocks in the Piedmont. The Ramapo fault is a structural and physiographic boundary between the two provinces.

The bedrock geology of the Morristown quadrangle has been studied for more than a century (e.g., Lewis and Kummel, 1910; Bayley et al., 1914; Lytle and Epstein, 1987; Volkert, 1988; and Drake et al., 1996). However, detailed mapping was not performed previously, and bedrock lithologies and structures lack continuity with the recent mapping of adjacent quadrangles. Therefore, the interpretations presented here supersede those shown on previous bedrock geologic maps of the area.

STRATIGRAPHY

The youngest bedrock in the quadrangle is Mesozoic in age and was deposited in the Newark basin that contains approximately 24,000 ft. of interbedded Upper Triassic to Lower Jurassic sedimentary and igneous rocks. Only the uppermost part of the stratigraphic succession is exposed in the map area. Sedimentary rocks of the Towaco and Bontion Formations underlie most of the Piedmont part of the area, but they crop out only sparsely because they are covered by widespread sediments of Quaternary to Recent age. Igneous rocks of the Hook Mountain Basalt support the minor relief in the southwest part of the map.

Mesoproterozoic Rocks

The oldest rocks are Mesoproterozoic in age. They include various granites and gneisses metamorphosed to granulite facies at about 1350 Ma, during the Oriskany phase of the Grenville orogeny (Volkert, 2004). Temperature estimates for this high-grade metamorphism are about 750°C from calcite-graphite thermometry (Peck et al., 2006).

Among the oldest Mesoproterozoic rocks are the Losee Suite, interpreted as a sequence of metamorphosed volcanic and plutonic rocks of calc-alkaline composition formed in a magmatic arc (Volkert, 2004). The Losee Suite includes quartz-diorite gneiss, biotite-quartz-diorite gneiss and hypersthene-quartz-plagioclase gneiss, and diorite gneiss. These rocks are spatially associated with a sequence of supracrustal rocks formed in a back-arc basin inboard of the Losee magmatic arc (Volkert, 2004). Supracrustal rocks include potassic felsitic gneiss, biotite-quartz-feldspar gneiss and pyroxene gneiss. Amphibolite is spatially associated with the Losee Suite and supracrustal rocks. Losee Suite and supracrustal rocks yield similar sensitive high-resolution ion microprobe (SHRIMP) U-Pb igneous crystallization ages of 1299 to 1248 Ma (Volkert et al., 2010).

Granitic rocks are widely distributed in the map area and they consist of hornblende granite of the Byram Intrusive Suite and microperthite granite of unknown age and affinity. Elsewhere in the Highlands, hornblende granite yields SHRIMP U-Pb igneous crystallization ages of 1184 to 1182 Ma (Volkert et al., 2010).

The youngest Mesoproterozoic rocks are small, irregular bodies of granite pegmatite that are undeformed and have discordantly intruded most other Mesoproterozoic rocks. Pegmatites regionally yield U-Pb igneous crystallization ages of 1044 to 987 Ma (Volkert et al., 2005).

STRUCTURE

Mesozoic bedding

Bedding in the Mesozoic rocks is somewhat varied and affected by two large, regional fold structures, the Watchung anticline and the New Vernon anticline. Beds dip mainly north, but in the southern part of the map they dip north and south, defining the limbs of the anticline, and in the axis of this fold they dip east. Bedding in the quadrangle displays two distinct trends. The dominant one strikes about N.80°W, and dips northeast, whereas the subordinate one strikes about N.05°E, and dips southeast. All beds range in dip from 3° to 21° and average 8°.

Proterozoic foliation

Crystallization foliation (the parallel alignment of mineral grains) in Mesoproterozoic rocks is an inherited feature from compressional stresses that deformed the rocks during high-grade metamorphism. Foliation is fairly uniform and strikes east to northeast at an average of N.61°E (fig. 1). The dip of all foliation is southeast and, less commonly, northwest at 20° to 90° and averages 50°.

Folds

Mesozoic rocks are deformed into the Watchung syncline, a broad, upright, north-plunging fold that is cored by the Bontion Formation. Its location and axial trend in the quadrangle are inferred because the Bontion Formation is covered by surficial deposits. The New Vernon anticline, in the southwest part of the map, is an upright open fold that plunges southeast. Beds on either limb dip gently at 3° to 11°. This fold is cored by the Towaco Formation. Hook Mountain Basalt forms the limbs.

Folds that deform Mesoproterozoic rocks were formed during the Grenville orogeny. The folds deform earlier-formed planar metamorphic fabrics, so they postdate the development of crystallization foliation. Characteristic fold styles include northeast to east-plunging antiforms and synforms that are north-west- to upright. These folds very locally have been refolded by southeast-plunging, open, upright antiforms and synforms that are well exposed in the Mendham quadrangle, to the west, but display limited expression in the map area. The plunge of mineral lineations in all folds averages 28° to N.76°E, parallel to the axes of major regional folds, and to the axes of minor folds in outcrop.

Faults

The Ramapo fault is a dominant structural feature that extends from the Gladstone quadrangle northeast into New York State (Drake et al., 1996). The fault has a complex and protracted history of movement that began during the Proterozoic. Multiple episodes of subsequent reactivation have left overprinting brittle and ductile fabrics that record kinematic indicators consistent with normal, reverse, and strike-slip movement. Mesoproterozoic rocks are preserved on the footwall of the fault and Mesozoic sedimentary and igneous rocks on the hanging wall. The fault strikes due north to N.40°E, and dips 50° southeast, as indicated by borings drilled in the Bernardsville quadrangle (Randell et al., 1959) and borings for Route 287 in the Pompton Plains quadrangle (Woodward Clyde Consultants, 1983). However, outcrops of ductily deformed Mesoproterozoic rocks, especially to the north in the Pompton Plains and Ramsey quadrangles, record mylonitic foliations of probable Proterozoic and Paleozoic age that dip steeply southeast at 60° to 80°.

A north-trending, steeply-dipping fault that is a splat of the Ramapo fault cuts the Bontion Formation, Hook Mountain Basalt and Towaco Formation in the southwest part of the map. It and other faults are characterized by brittle deformation fabric, and they appear to be of limited strike length and displacement.

The Powder Mill fault, named for its good exposure in the Powder Mill area of the map, extends from the Chester quadrangle northeast to the Bontion quadrangle, where it borders the east side of the Rockaway Valley. Mesoproterozoic rocks are present on both sides of the fault along its entire length. The fault strikes N.40°E, and dips about 60° southeast. It records dip-slip reverse movement sense, and it is characterized by brittle deformation fabric that includes retrogression of mineral phases, chlorite or epidote-coated fractures or slickensides, and (or) close-spaced fracture cleavage.

The Mendham fault extends through the west part of the map area where it contains Mesoproterozoic rocks on both sides. This fault was named the Flemington fault by Volkert et al. (1990) and correlated to a Mesozoic border-fault segment, but it is here reinterpreted as an older fault that is cut by Mesozoic faults. To the east, the Mendham fault is cut off by the Ramapo fault, and to the southwest it merges with, or becomes, the Tewksbury fault in the Calton quadrangle. The Mendham fault strikes east-northeast and dips about 40° toward the north. It records reverse movement sense and is characterized mainly by brittle deformation fabric that overprints an earlier ductile deformation fabric.

Mesoproterozoic rocks are also deformed by small northeast or northwest-trending faults, most of which are limited to single outcrops. These faults are typically no more than a few feet wide and are characterized by brittle deformation fabric.

Joints

Joints are a dominant structural feature in all rocks in the quadrangle. Those in Mesozoic sedimentary rocks are characteristically planar, moderately well formed, and unmineralized, except near

faults. Surfaces are smooth and, less commonly, irregular. Joints in sandstone are better developed than in siltstone and shale. Joints are spaced from 1 foot to several feet apart, except near faults where they are 1 foot apart. Two dominant joint sets are present in the sedimentary rocks that strike at an average of N.65°E, and N.30°W. Northeast-striking joints dip mainly northwest and northwest-striking joints dip mainly southwest. The dip of all joints averages 83°.

Joints in Mesozoic igneous rocks are of two types, columnar (cooling) and tectonic. Columnar joints are present in all basalt formations in the area. They are characteristically polygonal, arrayed radially and varied in height and spacing. A comprehensive study of the origin and orientation of cooling joints in the basalts was undertaken by Faust (1978). Tectonic joints are present in all basalt formations, but they are commonly obscured by the more pervasively cooling joints. Tectonic joints are planar, moderately to well formed, smooth to slightly irregular, steeply dipping, unmineralized, and are spaced from a few feet to tens of feet apart. In outcrops near faults, spacing is 1 foot or less apart and surfaces are locally mineralized by calcite and (or) chlorite.

The dominant joint orientation in Mesoproterozoic rocks is nearly perpendicular to the strike of crystallization foliation, and this relationship is a consistent feature observed throughout the Highlands (Volkert, 1996). Joints are characteristically planar, moderately well formed, moderately to widely spaced, and moderately to steeply dipping. Surfaces are smooth, and less commonly, slightly irregular. They are typically unmineralized except near faults where they are coated by chlorite and (or) epidote. Joints are variably spaced from 1 foot to tens of feet apart. Those developed in massive rocks such as granite are more widely spaced, irregularly formed and more discontinuous than joints in layered gneisses. Joints formed near faults are spaced 2 feet or less apart. The dominant joint set averages N.30°W, fig. 2) and dips nearly equally to the northeast and southwest. A subordinate set strikes about N.50°E, and dips mainly northeast. The average dip of all joints is 75°.

ECONOMIC RESOURCES

Mesoproterozoic rocks were quarried for dimension stone and aggregate north of Morris Plains, and also north of Kemble Mountain. Small, unnamed mine workings that were exploratory prospects for iron ore (magnetite) are visible southeast of Powder Mill Pond, and at two places south of Watnong Mountain. They are not shown on historic maps of the area, nor are they described in the historic literature, so information about them is unavailable.

NATURALLY OCCURRING RADIATION

Background levels of naturally occurring radioactivity were measured in Mesozoic bedrock outcrops using a hand-held Micro R meter and the results are given in the individual map unit descriptions. In general, basaltic yield consistently low readings of about 6 Micro R/Hr regardless of stratigraphic position, texture, or composition. Sedimentary units yield higher, more varied readings that range from 9 to 21 Micro R/Hr and appear to be related mainly to grain size. Values recorded from sandstone and pebbly sandstone are lower than those in siltstone and shale, suggesting that clay minerals may be the hosts for radiogenic mineral phases.

DESCRIPTION OF MAP UNITS

NEWARK BASIN

Bontion Formation (Lower Jurassic) (Olson, 1980) – Reddish-brown to brownish-purple, fine-grained, commonly micaceous sandstone, siltstone, and mudstone (Jb), in fining-upward sequences, mostly 5 to 13 ft. thick. Red, gray, and brownish-purple siltstone and block, blocky, partly dolomitic siltstone and shale are common, and less common, in unit. Irregular mud cracks, symmetrical ripple marks, hummocky and trough cross-laminated beds, burrows, and evaporite minerals are abundant in red siltstone and mudstone. Gray, fine-grained sandstone may have carbonized plant remains, and reptile footprints occur in middle and upper parts of unit. Conglomerate and conglomeratic sandstone (Jbc) that contains subangular to subrounded pebbles-to-boulders of Mesoproterozoic rocks and less abundant Paleozoic quartzite, shale, and dolomite, and Jurassic basalt in a matrix of coarse brown sand interfinger with the upper part of unit along the Ramapo fault. Maximum thickness regionally is about 1,640 ft. Levels of natural radioactivity range from 13 to 15 (mean=14) Micro R/Hr in reddish-brown lithologies, 15 to 17 (mean=16) Micro R/Hr in gray lithologies, and 11 to 13 (mean=12) Micro R/Hr in conglomerate and conglomeratic sandstone.

Hook Mountain Basalt (Lower Jurassic) (Olson, 1980) – Dark greenish-gray to black, fine-grained, amygdaloidal basalt composed of plagioclase, clinopyroxene, and iron-titanium oxides. Contains small spherical to tubular gas-escape vesicles above flow contacts, some of which are filled by zeolite minerals or calcite. Elsewhere unit contains dark-gray, coarse-grained gabbro composed of clinopyroxene and plagioclase grains as much as 0.5 in. long at several stratigraphic intervals. Gabbro has sharp upper contacts and gradational lower contacts with fine-grained basalt. Unit consists of at least two, and possibly three major flows. Base of lowest flow is intensely vesicular. Tops of flows are weathered and vesicular. Maximum thickness regionally is 360 ft. Levels of natural radioactivity range from 4 to 10 (mean=6) Micro R/Hr.

Towaco Formation (Lower Jurassic) (Olson, 1980) – Reddish-brown to brownish-purple, buff, olive-tan, or light olive-gray, fine to medium-grained, micaceous sandstone, siltstone, and silty mudstone in fining-upward sequences 3 to 10 ft. thick. Unit consists of at least eight sequences of gray, greenish-gray, or brownish-gray, fine-grained sandstone, siltstone, and calcareous siltstone, and black microlaminated calcareous siltstone and mudstone with diagnostic pollen, fish, and dinosaur tracks. Gray, fine-grained sandstone has carbonized plant remains. Irregular mud cracks and symmetrical ripple marks may be present. Sandstone is often hummocky and trough cross-laminated, and siltstone commonly planar laminated or bioturbated and indistinctly laminated to massive. Several ft. of unit have been thermally metamorphosed along the contact with Hook Mountain Basalt. Conglomerate and conglomeratic sandstone (Jtc) that contains subrounded clasts of quartzite and quartz in matrix of buff or tan, sand to silt interfinger with the unit along the Ramapo fault. Maximum thickness regionally is about 1,250 ft. Levels of natural radioactivity range from 12 to 21 (mean=15) Micro R/Hr in reddish-brown lithologies, 13 to 20 (mean=16) Micro R/Hr in gray lithologies and 9 to 13 (mean=11) Micro R/Hr in conglomerate and conglomeratic sandstone.

Preakness Basalt (Lower Jurassic) (Olson, 1980) – Dark greenish-gray to black, fine-grained basalt composed of plagioclase, clinopyroxene, and iron-titanium oxides. Contains small spherical to tubular gas-escape vesicles above scoriaceous flow contacts, some of which are filled by zeolite minerals or calcite. Dark-gray, coarse to very-coarse-grained gabbro composed of clinopyroxene grains as much as 0.5 in. long and plagioclase grains as much as 1.0 in. long occurs at several stratigraphic intervals but is most abundant in the lowest flow. Gabbro has sharp upper contacts and gradational lower contacts with fine-grained basalt. Unit consists of at least three major flows, the tops of which are marked by prominent vesicular zones as much as 8 ft. thick. Radiating slender columns 2 to 24 in. wide, due to shrinkage during cooling, are abundant near the base of the lowest flow. A bed of reddish-brown siltstone 6 to 25 ft. thick separates the lower flows. Maximum thickness is about 1,040 ft. Levels of natural radioactivity range from 3 to 8 (mean=6) Micro R/Hr. Unit is not exposed in the map area and is shown in cross section only.

NEW JERSEY HIGHLANDS

Granite pegmatite (Mesoproterozoic) – Pinkish-gray or buff-weathering, pinkish-white or light-pinkish-gray, very coarse-grained, massive, unfoliated granite composed of microcline microperthite, quartz, oligoclase, and hornblende. Commonly spatially associated with hornblende granite, but intrudes most Mesoproterozoic rocks in the map area.

Vernon Supersuite (Volkert and Drake, 1996)
Byram Intrusive Suite (Drake et al., 1991)

Hornblende granite (Mesoproterozoic) – Pinkish-gray or buff-weathering, pinkish-white or light-pinkish-gray, medium- to coarse-grained, foliated granite composed of microperthite, microcline microperthite, quartz, oligoclase, and hornblende. Locally contains zircon, apatite, and magnetite.

Back Arc Supracrustal Rocks

Potassic felsitic gneiss (Mesoproterozoic) – Light-gray or pinkish-buff-weathering, pinkish-white or light-pinkish-gray, medium-grained, moderately foliated gneiss composed of quartz, microcline microperthite, oligoclase, and biotite. Garnet, sillimanite, and magnetite are less common.

Biotite-quartz-feldspar gneiss (Mesoproterozoic) – Pale pinkish-white, pinkish-gray or gray-weathering (Yb), locally rusty (Yb), pinkish-gray, tan, or greenish-gray, medium-grained, layered and foliated gneiss containing microcline microperthite, oligoclase, quartz, biotite, garnet, and sillimanite. Graphite and pyrrhotite are confined to the variant that weathers rusty. This variant is commonly spatially associated with pyroxene gneiss and (or) quartzite that contains biotite, feldspar, and graphite.

Pyroxene gneiss (Mesoproterozoic) – Light-gray or white-weathering, greenish-gray, medium-grained, layered and foliated gneiss containing oligoclase, clinopyroxene, and local quartz, titanite, magnetite, and scapolite. Spatially associated with pyroxene amphibolite and biotite-quartz-feldspar gneiss.

Magmatic Arc Rocks

Losee Metamorphic Suite (Drake, 1984; Volkert and Drake, 1999)

Quartz-diorite gneiss (Mesoproterozoic) – White-weathering, light-greenish-gray, medium- to coarse-grained, moderately layered and foliated gneiss composed of oligoclase or andesine, quartz, and variable amounts of hornblende, clinopyroxene and biotite. Commonly contains thin, conformable layers of amphibolite but they are not shown on the map.

Biotite-quartz-oligoclase gneiss (Mesoproterozoic) – White or light-gray-weathering, medium-gray or greenish-gray, medium- to coarse-grained, layered and foliated gneiss composed of oligoclase or andesine, quartz, biotite, and local garnet. Some outcrops also contain hornblende. Unit grades into quartz-diorite gneiss with decrease in biotite.

Hypersthene-quartz-plagioclase gneiss (Mesoproterozoic) – Gray or tan-weathering, greenish-gray or brownish-gray, medium-grained, foliated gneiss composed of andesine or oligoclase, quartz, clinopyroxene, hornblende, and hypersthene. Commonly contains conformable layers of amphibolite and mafic quartz-plagioclase gneiss.

Diorite Gneiss (Mesoproterozoic) – Light-gray or tan-weathering, greenish-gray or brownish-gray, medium-grained, massive, foliated rock containing andesine or oligoclase, clinopyroxene, hornblende, and hypersthene. Locally contains thin layers having the composition of amphibolite.

Other Rocks

Microamphibole granite (Mesoproterozoic) – Tan or buff-weathering, light-greenish-gray, medium- to coarse-grained, massive, foliated granite composed of microamphibole to microperthite, quartz that is locally brown rust-stained, oligoclase, and hornblende. Locally contains minor amounts of biotite, zircon, clinopyroxene, and magnetite. Relationship of unit to intrusive rocks of the Vernon Supersuite is unknown.

Amphibolite (Mesoproterozoic) – Gray or grayish-black, medium-grained, foliated gneiss composed of hornblende and andesine. Some variants contain biotite and (or) clinopyroxene. Amphibolite associated with the Losee Suite is metavolcanic in origin. Amphibolite associated with mesosedimentary rocks may be metacalcic or metasedimentary in origin. Both types are shown undifferentiated on the map.

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EXPLANATION OF MAP SYMBOLS

Contact - Dotted where concealed
Fault - Dotted where concealed; Bar and ball show dip of fault plane.
Normal fault - U, upthrown side; D, downthrown side
Reverse fault - U, upthrown side; D, downthrown side

FOLDS

Folds in Mesozoic rocks showing trace of axial surface, direction of dip of axis, and direction of plunge
Syncline
Anticline
Folds in Mesoproterozoic rocks showing trace of axial surface, direction of dip of limbs, and direction of plunge
Synform
Antiform
Overturned synform
Overturned antiform

PLANAR FEATURES

Strike and dip of inclined beds
Strike and dip of crystallization foliation
Inclined
Vertical
Strike and dip of mylonitic foliation

LINEAR FEATURES

Bearing and plunge of mineral lineation in Mesoproterozoic rocks

OTHER FEATURES

Abandoned rock quarry
Abandoned magnetite mine
Bedrock float used to construct map
Boring - Rock type at bottom: B, basalt; S, sandstone, siltstone, shale; C, conglomerate. Data from Stanford (2006).
Form line showing foliation in Mesoproterozoic rocks. Shown in cross section only.

CORRELATION OF MAP UNITS

NEWARK BASIN
Jbc Jb
Jtc Jt
Jc Jc
Jb Jb

UNCONFORMITY

NEW JERSEY HIGHLANDS
Yp

INTRUSIVE CONTACT
New Jersey Supersuite
Byram Intrusive Suite
Yh Yh

INTRUSIVE CONTACTS
Back Arc Supracrustal Rocks
Yb Yb Yb Yb

MAGMATIC ARC ROCKS
Losee Metamorphic Suite
Yo Yo Yh Yo

OTHER ROCKS
Ya

OTHER FEATURES

REFERENCES CITED AND USED IN CONSTRUCTION OF MAP

Figure 1. Rose diagram of crystallization foliation orientations in Mesoproterozoic rocks. Sector size = 10° n = 119

Figure 2. Rose diagram of joint orientations in Mesoproterozoic rocks. Sector size = 10° n = 225

**BEDROCK GEOLOGIC MAP OF THE MORRISTOWN QUADRANGLE
ESSEX AND MORRIS COUNTIES, NEW JERSEY**

by
Richard A. Volkert
2013

Bedrock geology mapped by R.A. Volkert in 1986, 1998 and 2011
Digital cartography by M.W. Girard
Research supported by the U.S. Geological Survey, National Cooperative
Geological Mapping Program, under USGS award number 99HQAG014
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