

Mapped by the Army Map Service. Edited and published by the United States Geological Survey Control by USC&GS and New Jersey Geodetic Survey Topography form aerial photographs by photogrammetric methods Aerial photographs taken 1942. Field check 1943. Culture revised by the United States Geological Survey 1954. Polyconic projection. 1927 North American datum 10,000-foot grid based on New Jersey coordinate system 1000-meter Universal Transverse Mercator grid ticks, zone 18.

SCALE 1:24,000 000 0 1000 2000 3000 4000 5000

Bedrock Geologic Map of the Bernardsville Quadrangle, **Morris and Somerset Counties, New Jersey**



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Bedrock geology mapped by R.A. Volkert and D.H Monteverde in 1984, 1996 and 2011. Digital cartography by R.S. Pristas. Reviewed by J. Fischer and E. Verbeek. Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under USGS award number 1434-HQ-97-AG-01802. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.



The quadrangle is in the central Passaic River drainage basin, and this river drains the eastern part of the quadrangle from north to south. The northeast part of the map, east of Basking Ridge Township, contains the Great Swamp, a large tract of poorly drained natural wetland underlain by sediments of Pleistocene and recent age (Stanford, 2008), deposited on bedrock of the Boonton Formation. STRATIGRAPHY Mesozoic Rocks The youngest bedrock in the quadrangle is Mesozoic and was deposited in the Newark basin, which contains approximately 24,600 ft. of interbedded Upper Triassic to Lower Jurassic sedimentary and igneous rocks. Mesozoic formations become progressively younger from west to east, although the stratigraphy is complicated by faults and broad, regional folds. Sedimentary units, from oldest to youngest, are the Passaic, Feltville, Towaco, and Boonton Formations. Most of these are well exposed, except for the Boonton Formation, which is now largely covered by unconsolidated sediments. Conglomeratic facies of the Towaco Formation locally crop out in the eastern part of the map. Igneous units are the Orange Mountain Basalt, Preakness Basalt, and Hook Mountain Basalt that support the moderate relief in the Piedmont part of the map. The Hook Mountain Basalt and Preakness Basalt contain coarse-grained layers and local basaltic pegmatite at several stratigraphic intervals that are mapped as gabbroid. Gabbroid and pegmatite layers within the Preakness Basalt are interpreted to have formed through fractionation from fine-grained basalt (Puffer and Volkert, 2001). Gabbroid layers within the Hook Mountain Basalt, although not exposed in the map area, formed through a similar process. Mesoproterozoic Rocks The oldest rocks in the quadrangle are Mesoproterozoic and include various granites and gneisses metamorphosed to granulite facies about 1050 Ma during the Ottawan phase of the Grenville orogeny (Volkert, 2004). Temperature estimates for this high-grade metamorphism are 769°C from calcite-graphite thermometry (Peck et al., 2006). The youngest Mesoproterozoic rocks are small, irregular bodies of granite pegmatite that are undeformed and have discordantly intruded most other Mesoproterozoic rocks. None of the pegmatites are large enough to be shown on the map, but they are most common in areas underlain by hornblende granite. Pegmatites regionally have yielded U-Pb zircon ages of 1004 to 987 Ma (Volkert et al., 2005). Granitic rocks are widely distributed in the map area. They include hornblende granite, alaskite and monzonite of the Byram Intrusive Suite, and monzonite of the comagmatic Lake Hopatcong Intrusive Suite, that together constitute the Vernon Supersuite (Volkert and Drake, 1998). Rocks of the Vernon Supersuite yield sensitive high-resolution ion microprobe (SHRIMP) U-Pb zircon ages of

INTRODUCTION

and straddles the boundary between the New Jersey Highlands and Piedmont Physiographic Prov-

inces. Mesoproterozoic rocks of the Highlands underlie the northwest part of the map, and Mesozoic

igneous and sedimentary rocks of the Piedmont underlie the remainder. The Ramapo fault is a struc-

tural and physiographic boundary between the two provinces.

1188 to 1182 Ma (Volkert et al., 2010).

The Bernardsville quadrangle is in north-central New Jersey, in Morris and Somerset Counties,

Among the oldest Mesoproterozoic rocks are those of the Losee Suite, a sequence of metamorphosed volcanic and plutonic rocks of calc-alkaline composition formed in a continental-margin magmatic arc (Volkert, 2004). The Losee Suite includes quartz-oligoclase gneiss, biotite-quartz-oligoclase gneiss, hornblende-quartz-oligoclase gneiss, 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). They include potassic feldspar gneiss, monazite gneiss, biotite-quartz-feldspar gneiss, clinopyroxene-quartz-feldspar gneiss, pyroxene gneiss, and amphibolite. Losee Suite and supracrustal rocks yield similar SHRIMP U-Pb zircon ages of 1299 to 1248 Ma (Volkert et al., 2010). STRUCTURE Mesozoic Bedding Bedding in the Mesozoic rocks is varied and affected by numerous faults, as well as by the location of the guadrangle at the southwest end of the Watchung Syncline. Beds dip north in the southern part of the map and generally south in the northern part, defining the gently-dipping limbs of the syncline. The strike of beds displays two populations that are about N.70°E. and N.50°W. (fig. 1). Beds range in dip from 2° to 56° and average 12°. 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 northeast at an average of N.47°E. (fig. 2). Foliations dip mainly southeast, and less commonly, northwest from 15° to 90° and average 56°. Mesozoic rocks are deformed into the Watchung Syncline, a broad, upright, northeast-plunging fold that dominates the structure in the Piedmont part of the map. The Boonton Formation crops out in the core of the fold and Preakness Basalt defines the limbs. Rocks in the northeast part of the map are part of the upright, southeast-plunging New Vernon anticline. This fold is cored by Towaco Formation, and Hook Mountain Basalt forms the limbs. Only the southern limb of the fold is present in the quadrangle. A complimentary upright, southeast-plunging syncline cored by Boonton Formation, and highly dissected by faults, is mapped south of the anticline. Folds that deform Mesoproterozoic rocks 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 antiforms and synforms that are northwest-overturned, southeast-overturned, or upright. Mineral lineations plunge gently northeast at 5° to 24° at an average of N.52°E., parallel to the axes of minor folds in outcrop and the axes of major folds.

The Ramapo Fault is a dominant structural feature that extends northeast from the Gladstone guadrangle (Houghton and Volkert, 1990) into New York State (Drake et al., 1996). The fault has a complex and protracted history of movement that began in the Proterozoic. Multiple episodes of subsequent reactivation have left overprinting brittle and ductile fabrics that record normal, reverse, and strike-slip movement. The fault strikes about N.40°E. and dips 50° southeast, as indicated by borings drilled at Bernardsville Township (Ratcliffe et al., 1990) and for Route 287 between Montville and Riverdale Boroughs (Woodward Clyde Consultants, 1983). However, outcrops of Mesoproterozoic rocks on the footwall of the fault, 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 85° (Volkert, 2010; 2011). A series of north- to northeast-striking, steeply dipping faults south of the Ramapo Fault displace the axis of the Watchung Syncline and formation contacts from a few hundred to as much as 1,000 feet. Some of the northeast faults may be splays of the Ramapo Fault. Northwest-striking faults cut the north faults and, therefore, appear to be younger. All faults are characterized by very closely-spaced joints, thin zones of breccia and (or) clayey-silty gouge, slickensides locally coated by chlorite and (or) calcite, and eroded gaps in outcrops. Slip lineations on fault surfaces record mainly oblique to high-angle dip-slip movement. Northeast faults strike N.10°E. to N.30°E. (fig. 3) and dip southeast, and less commonly, northwest. North faults strike about N.05°W. (fig. 3) and dip nearly equally west and east. The average dip of all faults is 83°. 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 those in siltstone and shale. Joints are spaced from <1 foot to several feet apart, except near faults where they are spaced <1 foot apart. Two dominant joint sets and a subordinate set are present in the sedimentary rocks. The strike of joints displays populations that are about N.10°E., N.25° W. and a subordinate set strikes about N.70°E. (fig. 4). Northeast striking joints dip southeast, and less commonly, northwest, and northwest striking joints dip southwest, and less commonly, northeast. The average dip of all joints is 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 pervasive cooling joints. Tectonic joints are planar, moderately to well formed, smooth to slightly irregular, steeply dipping, unmineralized, and varied in their spacing from a few feet to tens of feet. 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 throughout the Highlands (Volkert, 1996). Joints are characteristically planar, moderately well formed, moderately to widely spaced, and moderately to steeply dipping. Surfaces of joints 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 spaced wider, irregularly formed and more discontinuous than in layered gneisses. Joints formed near faults are spaced 2 feet or less apart. The dominant joint set strikes N.20°W. to N.70°W. and averages N.32°W. (fig. 5). The dip is nearly equal to the northeast and southwest. Subordinate sets strike about N.45°E. and N.70°E. and dip mainly northwest. The average dip of all ioints is 75°. ECONOMIC RESOURCES Lower Jurassic Preakness Basalt was quarried near Bernardsville Borough for use as aggregate and dimension stone and Hook Mountain Basalt was guarried near Millington. A small, unnamed mica mine in Mesoproterozoic gneiss at Bernardsville was likely worked during the 19th century, but no information is available on the mine.

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 under the individual map unit descriptions. In general, basalts 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 from siltstone and shale, suggesting that clay minerals may be the host for the radiogenic phases.

Sector size = 10

Figure 1. Rose diagram of bedding orientations in Mesozoic sedimenatry rocks.



Biotite-quartz-feldspar gneiss (Mesoproterozoic) – Pale pinkish-white-weathering, pinkish-gray and gray-weathering (Yb), locally rusty (Ybr), gray, tan, or greenish-gray, medium-to coarse-grained, moderately 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 thin, moderately foliated to well-layered quartzite that contains biotite, feldspar, and graphite.

Clinopyroxene-quartz-feldspar gneiss (Mesoproterozoic) - Pinkish-gray or pinkish-buffweathering, white to pale-pinkish-white, medium-grained, foliated gneiss composed of microcline, quartz, oligoclase, clinopyroxene, and trace amounts of titanite and mag-



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BEDROCK GEOLOGIC MAP OF THE BERNARDSVILLE QUADRANGLE MORRIS AND SOMERSET COUNTIES, NEW JERSEY **GEOLOGIC MAP SERIES GMS 12-2**



EXPLANATION OF MAP SYMBOLS
 Contact - Dotted where concealed. Dashed and queried where uncertain.

Fault - Dotted where concealed. Dashed and queried where uncertain. **Normal fault -** U, upthrown side; D, downthrown side. Bar and ball show direction of dip of fault plane. **Reverse fault -** U, upthrown side; D, downthrown side. Bar and ball show direction of dip of fault plane. High-angle fault of unknown movement. FOLDS

Folds in Mesozoic rocks showing trace of axial surface, direction of dip of limbs, and direction of plunge. → Syncline

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 FEATUR

Strike and dip of crystallization foliation Inclined

- **-**Vertica
- _____ Strike and dip of inclined beds LINEAR FEATURES
- →¹⁸ Bearing and plunge of mineral lineation in Proterozoic rocks
- OTHER FEATURES Active rock quarry
- Abandoned rock quarry
- **Abandoned mica mine ▲**
- Bedrock outcrop or float used in construction of map
- XXXXXX Scoriaceous flow contact
- Boring log or water-well record from Stanford (2008) — — Form lines showing foliation in Proterozoic rocks. Shown in cross section only.



Figure 4. Rose diagram of joint orientations in Mesozoic sedimentary rocks.



Figure 5. Rose diagram of joint orientations in Mesoproterozoic rocks.

