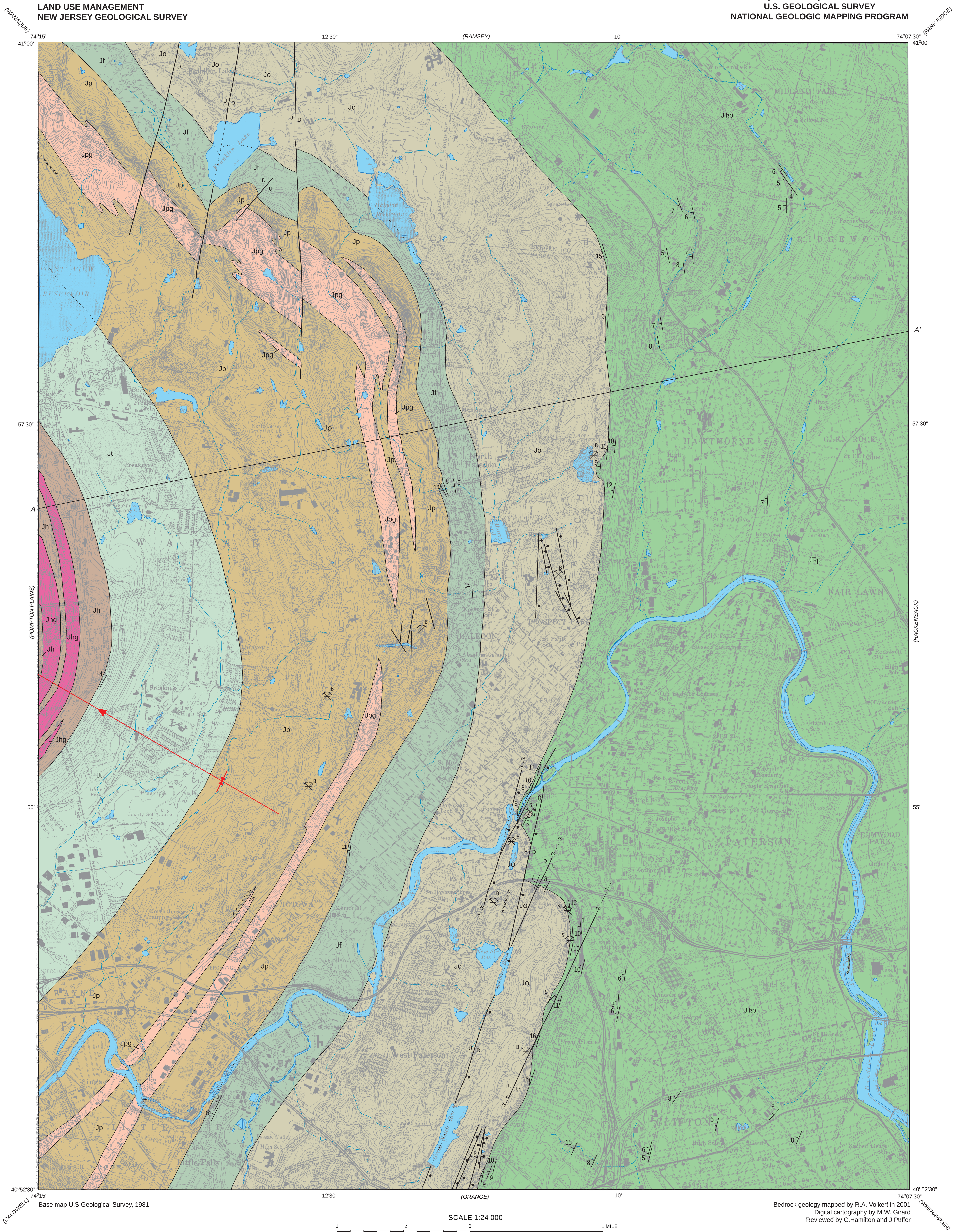
DEPARTMENT OF ENVIRONMENTAL PROTECTION
LAND USE MANAGEMENT
NEW JERSEY GEOLOGICAL SURVEY

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY
NATIONAL GEOLOGIC MAPPING PROGRAM

BEDROCK GEOLOGIC MAP OF THE PATERSON QUADRANGLE PASSAIC, ESSEX, AND BERGEN COUNTIES, NEW JERSEY GEOLOGIC MAP SERIES GMS 06-6



Base map U.S Geological Survey, 1981

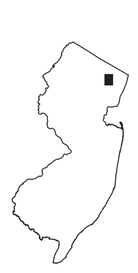
Bedrock geology mapped by R.A. Volkert in 2001
Digital cartography by M.W. Girard
Reviewed by C.Hamilton and J.Puffer

SCALE 1:24 000

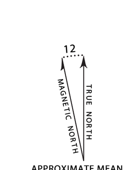
1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER



LOCATION IN NEW JERSEY

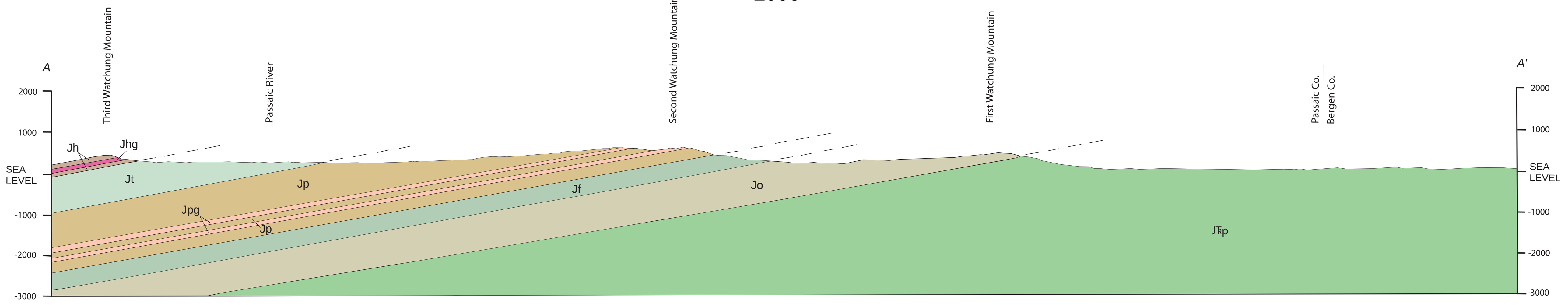


BEDROCK GEOLOGIC MAP OF THE PATERSON QUADRANGLE PASSAIC, ESSEX, AND BERGEN COUNTIES, NEW JERSEY

by

Richard A. Volkert

2006



EXPLANATION OF MAP SYMBOLS

Contact - Dotted where concealed

Faults - queried where uncertain. U, upthrown side; D, downthrown side. Ball shows direction of dip

Syncline showing trace of axial surface, and direction of plunge

PLANAR FEATURES

Strike and dip of inclined beds

OTHER FEATURES

Abandoned rock quarry - B, basalt; S, sandstone

Active rock quarry

x x x x Exposed basalt flow contact

DESCRIPTION OF MAP UNITS

Jh / Jhg Hook Mountain Basalt (Lower Jurassic) (Olsen, 1980a) - Dark-greenish-gray to black, generally fine-grained and very locally medium- to coarse-grained, amygdaloidal basalt composed of plagioclase, clinopyroxene, and iron-titanium oxides. Contains small spherical to tubular gas-escape vesicles, some filled by zeolite minerals, quartz, or calcite, typically above flow contacts. Consists of at least two, and possibly as many as three major flows. Base of lowest flow is intensely vesicular. Tops of flows are weathered and vesicular. Unit contains dark-gray, coarse-grained gabbroid (Jhg) composed of clinopyroxene and plagioclase grains up to 0.5 in. long that occurs at several stratigraphic intervals in the unit but is most abundant in the lowest flow. Gabbroid has sharp upper contacts and gradational lower contacts with more typical finer-grained basalt. Maximum thickness regionally is 361 ft. Levels of natural radioactivity measured from outcrops range from 5 to 8 Micro R/Hr (mean = 6) and show no variability between basalt and gabbroid.

Jt Towaco Formation (Lower Jurassic) (Olsen, 1980a) - 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. Irregular mudcracks and symmetrical ripple marks are present. Sandstone is often hummocky and trough cross-laminated, and siltstone commonly planar laminated or bioturbated and indistinctly laminated to massive. As much as 2 ft. of unit have been thermally metamorphosed along the contact with the Hook Mountain Basalt. Maximum thickness is about 1,250 ft. Levels of natural radioactivity measured in outcrops of reddish-brown sandstone and siltstone range from 12 to 21 MicroR/Hr (mean = 15) in reddish-brown lithologies and 13 to 20 MicroR/Hr (mean = 16) in gray lithologies.

Jp / Jpg Preakness Basalt (Lower Jurassic) (Olsen, 1980a) - Dark-greenish-gray to black, fine-grained, dense, hard basalt composed mainly of intergrown calcic plagioclase and clinopyroxene. Contains small spherical tubular gas-escape vesicles, some filled by zeolite minerals, quartz, or calcite, just above scoriaceous flow contacts. Dark-gray, coarse- to very-coarse-grained gabbroid (Jpg) composed of clinopyroxene grains up to 0.5 in. long and plagioclase grains up to 1.0 in. long occurs at several stratigraphic intervals but is thickest in the middle to upper part of the first flow. It has been described in detail by Puffer and Volkert (2001) from exposures in the Chatham quadrangle. Gabbroid has sharp upper contacts and gradational lower contacts with more typical finer-grained basalt. Unit consists of at least three major flows, the tops of which are marked by prominent vesicular zones up to 8 ft. thick. The first flow ranges in thickness from 415 to 475 ft. in the area, but is as much as 514 ft. thick regionally. It is overlain by a thin, 6 to 25 ft.-thick sequence of interbedded reddish-brown siltstone, shaly siltstone, and shale (Jps1). It is well exposed in the Caldwell quadrangle and is known elsewhere from water well record data. The second flow is about 192 ft. thick in the area. It is overlain by 2.5 ft. or more of thin-bedded, reddish-brown sandstone to siltstone (Jps2) known only from drill-core in this quadrangle and the Caldwell quadrangle (Fedosh and Smoot, 1988; Volkert, 2006). Radiating slender columns 2 to 24 in. wide, due to shrinkage during cooling, are abundant near the base of the lowest flow. Maximum thickness of unit is about 1,040 ft. Levels of natural radioactivity measured from outcrops of basalt range from 5 to 7 Micro R/Hr (mean = 6) and show no variability between basalt and gabbroid.

Jf Feltville Formation (Lower Jurassic) (Olsen, 1980a) - Reddish-brown, or light-grayish-red, fine- to coarse-grained sandstone, siltstone, shaly siltstone, and silty mudstone, and light- to dark-gray or black, locally calcareous siltstone, silty mudstone, and carbonaceous limestone. Upper part of unit is predominantly thin- to medium-bedded, reddish-brown siltstone and locally cross bedded sandstone. These grade upward into massive-bedded, medium-grained sandstone with thin pebbly sandstone interbeds that occur directly beneath the contact with the Preakness Basalt (Jp). Reddish-brown sandstone and siltstone are moderately well sorted, commonly cross-laminated, and interbedded with reddish-brown, planar-laminated silty mudstone and mudstone. Two thin, laterally continuous sequences, each up to 10 ft. thick of dark-gray to black, carbonaceous limestone, light-gray limestone, medium-gray calcareous siltstone, and gray or olive, desiccated shale to silty shale occur near the base and, along with the red beds between, comprise the Washington Valley Member of Olsen (1980b). Gray beds contain fish, reptiles, arthropods, and diagnostic plant fossils. As much as 2 ft. of Feltville have been thermally metamorphosed along the contact with the Preakness Basalt (Jp). Thickness of unit ranges from 450 to 510 ft. regionally, but thins to about 400 ft. in the map area. Levels of natural radioactivity measured from outcrops of reddish-brown sandstone and siltstone range from 9 to 12 Micro R/Hr (mean = 10.4).

Jo Orange Mountain Basalt (Lower Jurassic) (Olsen, 1980a) - Dark-greenish-gray to black, fine-grained, dense, hard basalt composed mostly of calcic plagioclase and clinopyroxene. Locally contains spherical to tubular gas-escape vesicles near flow tops, some filled by zeolite minerals, quartz, or calcite, or lined with prehnite, and amygdalar zones, typically above base of flow contact. Unit consists of three major flows that are separated in places by a weathered zone, a bed of thin reddish-brown siltstone, or by volcaniclastic rock. Lower part of upper flow is locally pillowed; upper part has pahoehoe flow structures. Middle flow is massive to columnar jointed. Lower flow is generally massive with widely spaced curvilinear joints and is pillowed near the top and locally at the base along the contact with Passaic Fm. Spaces between pillows are commonly lined with zeolites, quartz, calcite, and prehnite. Individual flow contacts are characterized by vesicular zones up to 8 ft thick. Thickness of unit is about 591 ft. Levels of natural radioactivity measured from outcrops range from 4 to 8 Micro R/Hr (mean = 5).

JŦp Passaic Formation (Lower Jurassic and Upper Triassic) (Olsen, 1980a) - Interbedded sequence of reddish-brown, and less often maroon or purple, fine-to coarse-grained sandstone and a pebbly sandstone, pebble conglomerate, siltstone, shaly siltstone, silty shale, and shale. Reddish-brown sandstone and pebbly sandstone are thin- to- thick- bedded, medium- to coarse-grained, planar to cross-bedded with local lensoidal interbeds of pebble conglomerate. Clasts in pebbly sandstone and conglomerate are mainly white or purple quartzite, but contain locally abundant carbonate clasts beneath Orange Mountain Basalt contact at North Haledon. Siltstone and shaly siltstone are thin-bedded, planar to cross-bedded, and locally mudcracked and ripple cross-laminated. Shaly siltstone, silty shale, and shale are fine-grained, very-thin- to thin-bedded, planar to ripple cross-laminated, locally fissile, bioturbated, and contain evaporite minerals, root casts and load casts. As much as 2 ft. of unit have been thermally metamorphosed and locally mineralized with sulfides along the east side of Garrett Mountain at Clifton. Maximum thickness regionally is about 11,500 ft. but an incomplete thickness of about 2,000 ft. occurs in the quadrangle. Levels of natural radioactivity measured from outcrops of reddish-brown siltstone, shaly siltstone and shale range from 5 to 19 MicroR/Hr (mean = 13).

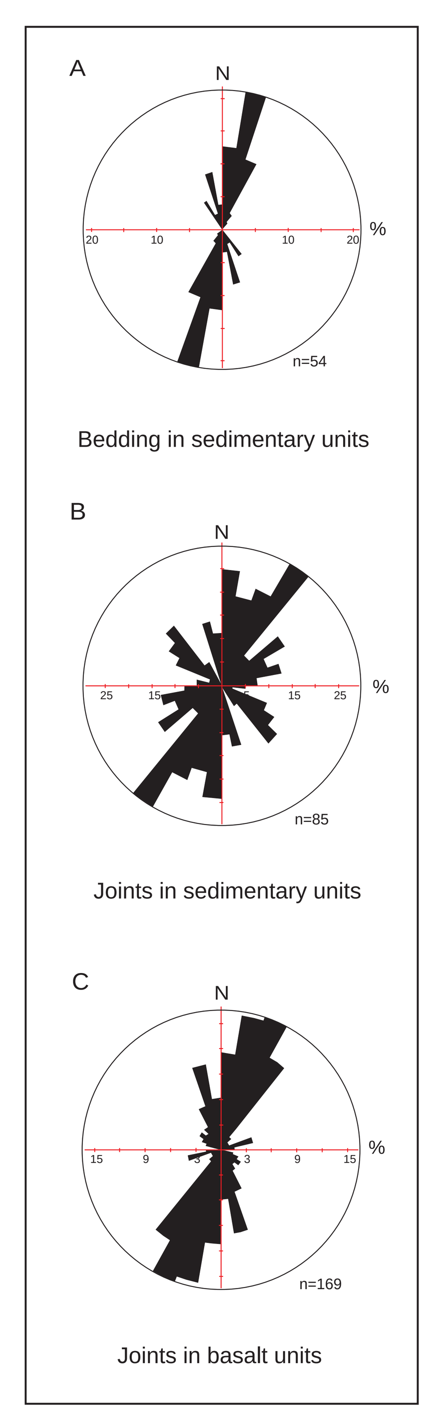


Figure 1. Bedrock structural features measured in outcrop (n=number of readings).

INTRODUCTION

The Paterson 7.5-minute quadrangle, in northern New Jersey, is located in Essex, Passaic, and Bergen Counties within a mixed commercial, industrial and residential setting. However, a large tract of land in the northern part of the map area along Preakness Mountain (High Mountain Park Preserve) remains undeveloped, as does a smaller tract at Garrett Mountain in the southern part of the area. The quadrangle occurs in the Passaic River drainage basin, and falls within the central part of New Jersey Department of Environmental Protection Watershed Management Area (WMA) 4 and the southeastern part of WMA 3. The Great Falls of Paterson, located in the Great Falls Historic District in downtown Paterson, is one of New Jersey's natural wonders. Developed in the Orange Mountain Basalt, the Great Falls has a width of 280 ft. and a vertical drop of 77 ft., making it the highest waterfall in the state.

The Paterson quadrangle occurs entirely within the Piedmont Physiographic Province. The dominant topography in the quadrangle consists of three subparallel, generally north-trending ridges, the First Watchung, Second Watchung, and Third Watchung Mountains, locally named Garrett Mountain, Preakness Mountain, and Packanack Mountain, respectively. The First Watchung Mountain attains a maximum elevation of 560 ft., the Second Watchung Mountain 885 ft., and the Third Watchung Mountain 487 ft.

STRATIGRAPHY

The Paterson quadrangle is underlain entirely by bedrock of Mesozoic age (Lower Jurassic and Upper Triassic). Bedrock occurs in the Newark basin, a northeast trending extensional basin in northern and central New Jersey that contains a total of approximately 24,600 ft. of interbedded sedimentary and igneous rocks. These consist of conglomerate, sandstone, siltstone, and shale of fluvial and lacustrine origin, and three interbedded tholeitic basalt units. However, only the upper part of this stratigraphic succession occurs in the quadrangle.

The general stratigraphic order of the bedrock in the quadrangle is one of progressive younging from east to the west. Sedimentary units are the Passaic Formation of Lower Jurassic and Upper Triassic age, and the Feltville and Towaco Formations both of Lower Jurassic age. These form a muted topographic surface that is now largely covered by unconsolidated glacial sediments. Igneous rocks from oldest to youngest are the Orange Mountain Basalt, Preakness Basalt, and Hook Mountain Basalt, all of Lower Jurassic age. The Hook Mountain and Preakness Basalts contain massive-textured, coarse-grained layers at several stratigraphic intervals (Volkert, 2000, 2006; Monteverde and Volkert, 2004) that are mapped as gabbroid. In addition, the Preakness Basalt contains very thin layers of locally developed, very-coarse-grained basaltic pegmatite. Gabbroid and pegmatite layers within the Preakness are interpreted by Puffer and Volkert (2001) to have formed through fractionation from finer-grained basalt in the Preakness. Gabbroid layers within the Hook Mountain Basalt likely formed through a similar process.

STRUCTURE

Bedding in the Mesozoic rocks displays a maxima at about N.07°E. as seen on a rose diagram (Fig. 1). The slight variablity in trend is a result of outcrop location in relation to a large, regional northwest-plunging syncline that extends through the western part of the quadrangle. In general, bedding on the southern limb trends toward the northeast, and bedding on the northern limb toward the northwest. Beds on either limb dip gently toward the west between 4° and 15° and average about 9°.

Small north-trending, brittle faults of Mesozoic age and of apparent limited displacement cut the formations in the map area. These faults range in width from <1 ft. to about 20 ft., with the wider faults often consisting of zones of multiple thin faults. All faults are characterized by any or all of the following: very close-spaced jointing; thin zones of breccia and (or) clayey-silt gouge; slickensides locally coated with chlorite and (or) calcite; and eroded gaps in basalt outcrops. Kinematic indicators on faults south of North Haledon, that consist of subhorizontal to gently north-plunging slip lineations on fault surfaces, constrain the predominant movement to right lateral strike-slip. Most of the mapped faults have steep dips of 75° to 90°.

Joints are a ubiquitous feature in all of the bedrock units. In the sedimentary units, northeast-trending joints are the most abundant and display a maxima at about N.32°E. as seen on a rose diagram (Fig. 1). These joints are characteristically planar, moderately well formed, and dip at an average of 83° mainly toward the southeast. Joint surfaces are typically unmineralized, except where proximal to faults, and are smooth and less commonly slightly irregular. Joints are variably spaced from <1 ft. to several feet. Those occurring in massive textured rocks such as sandstone tend to be better developed and more continuous than joints developed in the finer-grained lithologies such as shaly siltstone and shale. Joints in the latter are commonly less penetrative and are discontinuous over short distances in outcrop. All joints formed proximal to faults are spaced much closer, typically on the order of < 2 ft.

Joints in the igneous rocks consist of two types, columnar (cooling) and tectonic. Columnar joints are present in all three of the Watchung basalts in the map area. They are charactaristically polygonal, arrayed radially and are quite variable in height and spacing. A comprehensive study of the characteristics of cooling joints in the Watchung basalts was preformed by Faust (1978). Tectonic joints occur in all three of the basalt formations but are commonly obscured by the more prevasive cooling joints. Tectonic joints are best developed in the Orange Mountain Basalt where they are typically planar, well formed, smooth to slightly irregular, steeply dipping, unmineralized, and variably spaced from a few feet to tens of feet. However, in outcrops that are fault proximal, joints are spaced on the order of a few inches to 1 ft. Northeast-trending strike joints are the most common and display a maxima at about N.11°E. as seen on a rose diagram (Fig. 1). A minor variant of this set displays a maxima at about N.10°W. Both sets dip steeply at an average of 83° mainly toward the northeast, and less commonly toward the southwest.

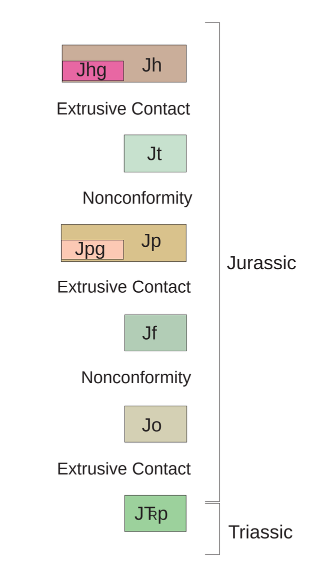
ECONOMIC RESOURCES

Lower Jurassic basalt was formerly quarried for use as aggregate and dimension stone from several locations in the quadrangle. In addition, Orange Mountain Basalt is currently quarried at Prospect Park and Clifton, and Preakness Basalt at Haledon. Sedimentary rock, predominantly sandstone, was quarried from the Passaic Formation in the Paterson area for use in the brownstone industry.

NATURALLY OCCURRING RADIATION

Background levels of naturally occurring radioactivity were measured in bedrock outcrops using a hand-held Micro R meter and the results are given under the individual rock unit descriptions. In general, basalts yield consistantly low Micro R/Hr readings regardless of stratigraphic position, texture, or composition. Sedimentary units yield higher and somewhat more variable readings that appear to be influenced mainly by grain size. Values recorded from sandstone and pebbly sandstone are lower than finer-grained siltstone and shale, suggesting that clay minerals are principal hosts of the radiogenic mineral phases. This appears to be true on a regional basis as well, based on measurements of various lithofacies of the Mesozoic sedimentary formations from eight 7.5-minute quadrangles in the Newark basin from New Brunswick north to Pompton Plains (R.A. Volkert, unpublished data).

CORRELATION OF MAP UNITS



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