

Table 1. Selected well and boring records

Well number	Permit number	Bedrock unit	Abbreviated log with depth and description	Well number	Permit number	Bedrock unit	Abbreviated log with depth and description
1	25-13808	0-8 8-27 27-164	clay clay gray and red shale trap rock	32	25-20463	0-1 1-35 35-55 55-68 68-153 153-253	fill clay and sand with small stones fine sand red clay, sand and stones red sandstone and clay red sandstone
2	25-11345	4-18 18-33 33-41 41-54 54-130	fill sandy clay silty sand fractured rock trap rock	33	26-04486	0-50 50-72 72-77 77-79 79-133 133-153 153-175	fine to coarse sand gravel, some cobbles fine sand trap rock trap rock soft, yellow and gray sandstone fine to coarse sand
3	25-22195	0-29 29-45 45-69 69-89 89-125	silt, some gravel red shale brownstone red shale red shale	34	26-09887	0-46 46-92 92-102 102-112 112-121 121-160 160-85 85-89	gravel, some sand trap rock clay fine gravel sand and gravel fine sand gravel red sandstone
4	25-22543	0-7 7-22 22-38 38-44 44-61 61-125	glacial erratic brown sand, gravel, some large stones brown silt fine sand, small clay layers gray trap rock light brown silt sand, gravel red, gray, brown shale	35	7	0-1 1-10 10-46 46-62 62-67 67-71 71-135 135-139	loam clay fine gravel sand and gravel fine sand gravel red sandstone
5	25-12953	0-11 11-33 33-41 41-89 89-125	sand clay hardpan, stones silt with red sandstone silt with red sandstone	36	25-12852	0-10 10-46 46-62 62-67 67-71 71-135 135-139	clay sand and clay sand and gravel clay clay sand and gravel red shale
6	26-02071	0-11 11-19 19-32 32-41 41-89 89-125	fill clayey sand hardpan silt silt silt silt	37	25-07101	0-4 4-25 25-55 55-65 65-71 71-135 135-139	topsoil clay sandy clay and silt sand coarse gravel silt sand, some gravel red hardpan red, gray, brown shale
7	26-03030	0-11 11-19 19-32 32-41 41-89 89-125	fill clayey sand hardpan silt silt silt silt	38	22-08468	0-78 78-258 258-303 303-309 309-314 314-324 324-338 338-352	basalt trap rock red shale and sandstone red shale and sandstone
8	25-10557	0-42 42-158 158-227 227-372 372-466	fine sand clay, layers of silt sand silt sand red shale and sandstone basalt	39	26-03701	0-8 8-34 34-45 45-48 48-59 59-69 69-79	basalt trap rock red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone
9	25-26385	0-8 8-13 13-14 14-26 26-43 43-46 46-96	fill gray clay and gravel dark brownish-gray silt clay grayish-brown silt clay dark reddish-gray silt sand sand and gravel	40	26-04430	0-13 13-68 68-81 81-86 86-91 91-96 96-101	red shale and sandstone red shale and sandstone
10	25-12425	0-8 8-23 23-41 41-49 49-57	basalt sand clay hardpan with stones silt sand and gravel fractured trap rock	41	26-04122	0-30 30-55 55-69 69-79 79-89	red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone
11	25-14144	0-10 10-20 20-80 80-114 114-118 118-125	red clayey sand gray silt, sandy gray clay brown sand with some silt, gravel brown to rust-clayey silt coarse sand red, brown shale	42	46-00205	0-45 45-108 108-120 120-123 123-124 124-125	sandy clay fine sand, few pebbles, some clay red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone
12	25-13383	0-8 8-19 19-37 37-42 42-53 53-62	silt silt Hardpan with gravel, large stones clay, gravel trap rock clay, silt, some sand and fine gravel	43	26-05686	0-21 21-29 29-46 46-51 51-58 58-69 69-79	hardpan silt sand hardpan red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone
13	25-14143	0-10 10-50 50-62 62-90 90-112 112-119	clayey silt clay, sandy in part clayey silt clay, hardpan, and stones clay and gravel trap rock	44	26-09226	0-58 58-61 61-115 115-120 120-123 123-124 124-125	hardpan red shale and sandstone red shale and sandstone
14	25-12183	0-15 15-20 20-40 40-80 80-150	handpan sand hardpan and boulders red sandstone red sandstone red sandstone	45	25-17995	0-9 9-30 30-41 41-46 46-51 51-58 58-69 69-79	sand silt red shale and large stones red shale with sandstone lenses red shale and sandstone red shale and sandstone red shale and sandstone red shale and sandstone
15	25-13436	0-15 15-20 20-40 40-80 80-150	handpan sand hardpan and boulders red sandstone red sandstone red sandstone	46	26-1701	0-5 5-24 24-28 28-30 30-186 186-202 202-300	sandy clay sandy boulders hardpan coarse gravel hardpan red shale and sandstone red shale and sandstone red shale and sandstone
16	25-11053	0-45 45-125 125-135 135-178	handpan, some boulders sand red hardpan red sandstone	47	26-11300	0-4 4-174 174-180	dirt trap rock red rock
17	25-14728	15-35 35-45 45-60 60-70 70-111 111-115 115-120	small gravel fragments clay and gravel coarse sand, some clay and gravel clay, some sand gravel sand red, gray shale	48	26-1547	0-67 67-209 209-218 218-200 200-300	sandy clay with rock fragments red sandstone sandstone red sandstone red sandstone
18	25-25959	0-1 1-30 30-40 40-472 472-485 485-500	red shale and sandstone decomposed red shale red shale topsoil clay, some boulders sandy hardpan with large rocks red, gray, black shale, some sandstone sandstone gray shale	49	46-203	0-40 40-62 62-80 80-84 84-89 89-94 94-99	clay, boulders partly rounded trap pebbles red sandstone and shale red sandstone red sandstone red sandstone red sandstone
19	26-04942	0-1 1-30 30-40 40-472 472-485 485-500	topsoil clay, some boulders sandy hardpan with large rocks red, gray, black shale, some sandstone sandstone gray shale	50	26-7878	0-10 10-35 35-270	overburden hardpan trap rock
20	26-08037	0-2.5 2.5-12.5 12.5-31.5	fill silt and clay, some fine sand gravel and sand, some clayey silt red sandstone	51	26-2290	0-39 39-285 285-320 320-330 330-340 340-350 350-360 360-370 370-380 380-390	red sandstone and red, gray shale clay and boulders trap rock red rock red rock red rock red rock red rock red rock red rock red rock
21	25-30670	0-8 8-25 25-30 30-45 45-55 55-60 60-61 61-104	fill silt and clay with boulders throughout sand silt and clay, trace sand and gravel sand, silt silt, trace sand sand, silt redish-brown siltstone	52	26-1673	0-3 3-12 12-19 19-200	dirt trap rock red rock sandstone
22	90-00145	0-60 60-66 66-86	sand, some silt and gravel silty clay decomposed red shale	53	26-2214	0-38 38-165 165-200	silt and clay red sandstone red sandstone
23	45-03340	0-2 2-8 8-26	topsoil clay and gravel red hardpan	54	26-5235	0-50 50-60 60-100 100-110 110-467 467-508	gravel, sand gravel, hardpan sand, boulders sand red shale red shale
24	25-13619	0-26 26-32 32-53 53-109 109-114 114-123 123-140	red hardpan sandstone clay and sandy clay hardpan and boulders cemented sand and gravel, some clay clay, silt clay, sandy clay red shale red shale red shale	55	26-14139	0-4 4-42 42-65 65-40 40-70 70-70 70-70	fill sand and brown clay broken rock red sandstone red sandstone red sandstone red sandstone
25	25-14012	0-10 10-60 60-400	overburden red hardpan red shale, brown, gray shale	56	26-1283	0-4 4-265 265-406	dirt trap sandstone
26	25-02177	0-3 3-11 11-78 78-83 83-87 87-128	fill black brack clay, silty clay brown hardpan red silty clay red shale	57	26-1607	0-7 7-165 165-750	dirt trap rock red sandstone
27	25-19777	0-16 16-82 82-95 95-99	sandy clay sand, gravel, hardpan red clay red shale	58	26-1048	0-8 8-380 380-602	overburden trap rock red rock
28	25-14167	0-5 5-29 29-60 60-55	fill clay and silt sand, silt, gravel till with some clay redish-brown shale and sandstone	59	26-2327	0-32 32-44 44-79 79-654 654-619	trap rock sandstone and trap rock red sandstone trap rock red shale
29	25-13631	0-41 41-47 47-161	clay, sandy clay red hardpan shale	60	26-4476	0-4 4-42 42-65 65-40 40-70 70-70 70-70	fill sand and brown clay broken rock red sandstone red sandstone red sandstone red sandstone
30	26-01039	0-36 36-100 100-126	fine sand clay and fill, some fine sand red hardpan red sandstone	61	25-4768	0-11 11-78 78-83 83-87 87-128	red sandstone red sandstone red sandstone red sandstone red sandstone
31	25-16303	0-5 5-18 18-32 32-48 48-456	clay sand, gravel, clay redish-brown hardpan arenaceous shale shale	62	25-4114	0-5 5-60 60-315 315-200 200-407 407-407	large cobble stones and clay very fine sand mixed with clay trap rock blue shale rock red shale rock red shale rock
				63	26-48055	0-30 30-70 70-110 110-125 125-280 280-285 285-348 348-400	silt sand, some clay and gravel sand, some gravel silt sand and gravel, some sand gray siltstone redish-brown, gray shale redish-brown siltstone redish-brown, gray shale basalt
				64	NJGS files	0-40 40-44 44-64 64-71 71-488 488-530 530-538 538-716	basalt coarse sand and gravel basalt brown siltstone and shale basalt 71-488 redish-brown sandstone gray sandstone redish-brown siltstone

INTRODUCTION

The Caldwell 7.5-minute quadrangle, in north-central New Jersey, is located in western Essex and eastern Morris Counties within a mixed commercial, industrial and residential setting. The quadrangle occurs in the southern part of the Passaic River drainage basin and the central and eastern parts of New Jersey Department of Environmental Protection Watershed Management Area #6. The Passaic River is the dominant drainage in the area and it connects with the Whippany and Rockaway Rivers in the northwest part of the quadrangle. Surface water impoundments in the southern part of the quadrangle (Canoe Brook #2 Reservoir, Orange Reservoir) supply potable water to the cities of East Orange and Orange in Essex County. The northwestern part of the map area is underlain by large expanses of natural wetland areas that include the Troy Meadows, Great Piece Meadows, Long Meadow, and Hatfield Swam. Smaller wetlands occur discontinuously to the southwest along the Passaic River and, collectively, these represent poorly drained areas underlain by glaucoconite sediments of Pleistocene age.

The Caldwell quadrangle is situated entirely within the Piedmont Physiographic Province and is underlain by igneous and sedimentary rocks of Mesozoic age. These occur in the Newark Basin, a northeast-trending extensional basin that extends through northern and central New Jersey. The Newark basin contains a total of approximately 24,000 ft. of interbedded Upper Triassic and Lower Jurassic sedimentary and igneous rocks, but not all of these units occur in the map area. Only the middle and upper parts of this succession are exposed within the quadrangle; these consist of sandstone, siltstone, and shale of fluvial and lacustrine origin, and three interbedded tholeiitic basalt units.

STRATIGRAPHY

The general stratigraphic order of bedrock units in the quadrangle is one of progressive younging from east to the west. Sedimentary units from oldest to youngest are the Passaic (Jp), Felville (Jf), Towaco (Jt), and Boonton (Jb) formations, all of Lower Jurassic age. The Felville Formation is a relatively narrow intermediate valley along, and west of, the Peckman and Rahway Rivers, whereas the other formations form broad, relatively featureless plains. The Boonton Formation does not crop out in the map area and is known mainly from boring logs and water-well records. Igneous units from oldest to youngest are the Orange Mountain Basalt (Jo), Preankness Basalt (Jp), and Hook Mountain Basalt (Jh) that form the First, Second, and Third Watchung Mountains, respectively, and provide the prominent topography in the quadrangle. The Preankness Basalt contains thin sedimentary units (Jps) above the first flow, and also contains conformable, coarse-grained to locally pegmatitic layers mapped as gabbro (Jg) that occur at several stratigraphic intervals. Puffer and Volkert (2001) interpreted the formation of gabbro and pegmatite layers through faciolation of finer-grained basalt in the Preankness.

STRUCTURE

The overall trend of the bedrock units is influenced by their location on the south limb of a broad, open, northwest-plunging anticline (Drake and others, 1998). Bedding of the sedimentary units closely parallels the trend of the igneous units and is generally quite uniform throughout the map area. Beds range in strike from N05°E to N33°E and average N19°E (Fig. 1) and they dip toward the northwest between 6° and 11° and average 9°.

A series of small brittle faults of relatively minor displacement that trend north to slightly northeast cut the basaltic of the map area. Faults have a mean dip of 10° to 13°. They consist of at least eight normal faults and mean dip of 84° toward the east. They range in width from <1 foot to about 20 feet, with the wider faults commonly consisting of zones of multiple thin joints. All faults are characterized by the following: very coarse-grained jointing; thin zones of breccia and iron clayey gouge; slickensides locally coated with pyrite or calcite, and eroded gaps in basalt outcrops as much as 3 feet wide. Kinematic indicators that consist of subhorizontal to gently north-plunging slip lineations on fault surfaces constrain the predominant movement to right-lateral strike-slip.

Faults cutting the Preankness Basalt were best exposed along Route 280, west of Pleasant Valley Way, until Spring 1999, when they were covered by the New Jersey Department of Transportation during slope stabilization along the roadway. Good examples of faults can still be observed along a small, unnamed stream in South Mountain Reservation south of the Orange Reservoir. The dominant fault in the map area is a north-northeast-trending normal fault in Livingston Township. It was identified primarily through subsurface boring logs and water well records that define offsets of the contact between the Hook Mountain Basalt and the Boonton Formation.

Joints are a ubiquitous feature in all bedrock units in the quadrangle. However, the paucity of outcrops of sedimentary rock prohibit the determination of a statistically dominant trend. Measured joints strike predominantly N46°E and N05°W (Fig. 1) and have a mean dip of about 86°. These joints are characteristically planar, moderately well sorted, and truncated, except where proximal to faults where they may contain sparse calcite as vein fill. Joint surfaces typically are smooth and less commonly irregular. Joints are variably spaced from <1 foot to several feet. Those occurring in sandstone tend to be more penetrative than joints developed in the finer-grained lithologies such as siltstone and shale. Joints in the latter are commonly less well developed and are continuous over short distances in outcrop. All joints formed proximal to faults are spaced much closer, typically at the order of <1 foot.

Joints in the igneous rocks consist of two types, columnar (cooling) and tectonic. Columnar joints are present in all of the basalts in the map area. They are characteristically polygonal, arranged radially and are quite variable in height and spacing. A comprehensive study of cooling joints in the Watchung basalts was performed by Faust (1976). Tectonic joints occur in all of the basalts but are commonly obscured by the more pervasive cooling joints. Tectonic joints are best preserved in the Orange Mountain Basalt where they are typically planar, moderate to 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 joint spacing is on the order of 1 foot or less. The principal joint trend in basalt is indistinguishable from the predominant fault trend and has a mean strike of N07°E (Fig. 1) and is a steeply easterly dip.

ECONOMIC RESOURCES

Lower Jurassic basalt was formerly quarried for use as aggregate and dimension stone from several locations in the quadrangle. Orange Mountain Basalt was quarried at South Orange and West Orange. Preankness Basalt was quarried at Caldwell and North Caldwell, and Hook Mountain Basalt was quarried at Livingston and Pine Brook. Sedimentary rocks, predominantly sandstone and shale, in the browerstown industry, were quarried from the Felville Formation at West Orange and from the Towaco Formation at Beaufort, west of Roseland.

NATURALLY OCCURRING RADIOACTIVITY

Background levels of naturally occurring radioactivity were measured in Mesozoic bedrock outcrops using a handheld Micro R meter and the results are given under the individual rock unit descriptions. In general, basalt yields consistently low readings of about 6 Micro R/hr regardless of stratigraphic position, texture, or composition. Sedimentary units yield higher and somewhat more variable readings ranging from 10 to 14 Micro R/hr 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 lithologies of the Mesozoic sedimentary formations from eight 7.5-minute quadrangles in the Newark basin from Newark through north to Pompton Plains (R.A. Volkert, unpublished data).

REFERENCES CITED AND USED IN CONSTRUCTION OF MAP

Drake, A.A., J., Volkert, R.A., Montevideo, D.H., Herman, G.C., Houghton, H.F., Parker, R.A., and Dalton, R.F., 1996, Bedrock Geologic Map of Northern New Jersey, U.S. Geological Survey Miscellaneous Investigations Series Map I-254-A, scale 1:100,000.

Fedosh, M.S., and Smoot, J.P., 1988, A cored stratigraphic section through the northern Newark Basin, New Jersey, in A.J. and Robinson, S.R., Jr., eds., Studies of the Early Mesozoic Basins of the eastern United States, U.S. Geological Survey Bulletin 1776, p. 19-24.

Faust, G.T., 1976, Joint systems in the Watchung basalt flows, New Jersey, U.S. Geological Survey Professional Paper 848, 46 p.

Hoffman, J., undated, Compilation of selected wells in the central Passaic Basin, unpublished database on file in the office of the New Jersey Geological Survey, Trenton, New Jersey.

Houghton, H.F., ca. 1990, unpublished data on file in the office of the New Jersey Geological Survey, Trenton, New Jersey.

Kummel, H.B., ca. 1900, unpublished data on file in the office of the New Jersey Geological Survey, Trenton, New Jersey.

Manspeizer, W., 1980, Rift tectonics related to volcanic structures, in Manspeizer, Warren, ed., Field Studies of New Jersey geology and guide to field trips: 52<sup>nd</sup> Annual Meeting of the New York State Geological Association, p. 314-350.

Montevideo, D.H., and Volkert, R.A., 2004, Bedrock geologic map of the Chatham quadrangle, Morris, Union, and Somerset Counties, New Jersey, New Jersey Geological Survey, GMS 0402, scale 1:24,000.

Olsen, P.E., 1980a, The latest Triassic and Early Jurassic formations of the Newark Basin (Eastern North America Newark Supergroup): Stratigraphy, structure and correlation, New Jersey Academy of Science Bulletin, v. 25, no. 2, p. 25-51.

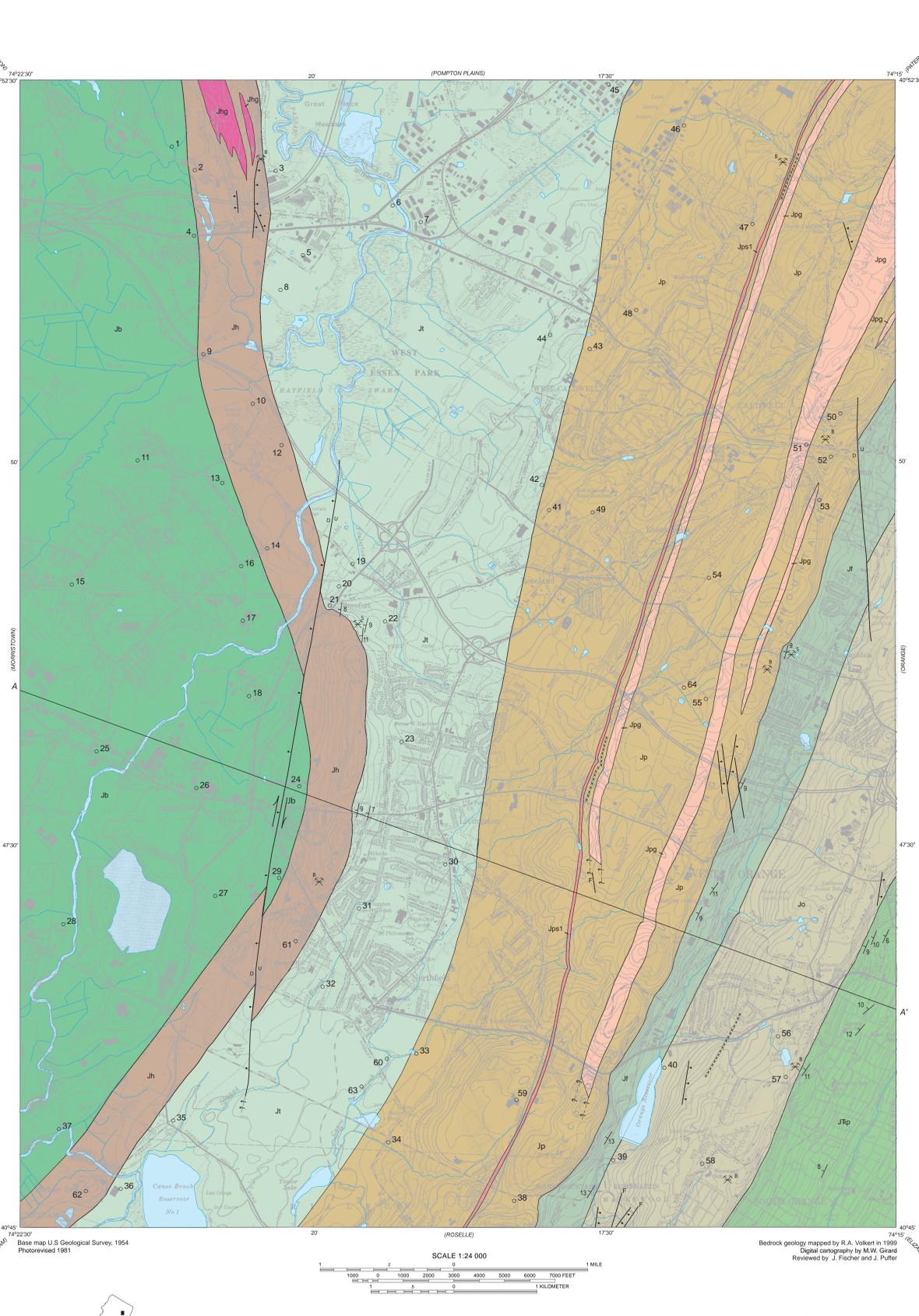
Olsen, P.E., 1980b, Fossil gravel levels of the Newark Supergroup in New Jersey, in Manspeizer, Warren, ed., Field Studies of New Jersey geology and guide to field trips: 52<sup>nd</sup> Annual Meeting of the New York State Geological Association, p. 350-368.

Parker, R.A., ca. 1990, unpublished data on file in the office of the New Jersey Geological Survey, Trenton, New Jersey.

Puffer, J.H., and Volkert, R.A., 2001, Pegmatite and gabbro layers in Jurassic Preankness and Hook Mountain Basalt, Newark Basin, New Jersey, Journal of Geology, v. 109, p. 985-1001.

Volkert, R.A., 2001, Bedrock geologic map of the Paterson quadrangle, Essex, Passaic, and Bergen Counties, New Jersey, unpub. map on file in the office of the New Jersey Geological Survey, Trenton, New Jersey, scale 1:24,000.

Volkert, R.A., and Montevideo, 1997, D.H., Bedrock geologic map of the Bernardsville quadrangle, Somerset and Morris Counties, New Jersey, unpub. map on file in the office of the New Jersey Geological Survey, Trenton, New Jersey, scale 1:24,000.



DESCRIPTION OF MAP UNITS

- Jb** Boonton Formation (Lower Jurassic) (Olsen, 1980a) - Reddish-brown to brownish-purple, fine-grained, commonly micaceous sandstone, siltstone, and mudstone, in thinning-upward sequences mostly 5 to 13 ft. thick. Includes brownish-purple siltstone and black, blocky, partly calcareous siltstone and shale commonly in the lower part of unit. Irregular mud cracks, fingering ripple marks, hummocky and trough cross-laminated beds, burrows, and evaporite minerals are abundant in siltstone and mudstone. Gray, fine-grained sandstone may have carbonized plant remains and ripple footprints in middle and upper parts of unit. Maximum thickness of unit regionally is about 1,640 ft.
- Jh** 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 spheroidal to tubular gas-escape vesicles, some filled by zeolite minerals or calcite, typically above flow contacts. Dermal tumuli structures described by Manspeizer (1980) are well exposed at Pine Brook. Hook Mountain Basalt 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 gabbro (Jg) composed of clinopyroxene and plagioclase grains up to 0.2 mm long that occur at several stratigraphic intervals in the unit, is most abundant in the lowest flow. Gabbro has sharp upper contacts and gradational lower contacts with more typical fine-grained basalt. Type section of unit occurs in the quadrangle along Interstate 80 west of Pine Brook. Maximum thickness of unit regionally is 361 ft. Levels of natural radioactivity measured from outcrops range from 5 to 8 (mean=6) Micro R/hr, and show no variability between basalt and gabbro.
- 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 silt clay 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. However, in the Bernardsville area it contains beds of light-gray, fine-grained calcareous sandstone interbedded with light-gray, reddish-brown, or light-greenish-gray, fine-grained quartzite sandstone that contains locally abundant carbonized plant remains (Volkert and Montevideo, 1997). Reddish-brown sandstone is moderately to moderately well sorted, commonly cross-laminated, and interbedded with reddish-brown, planar-laminated siltstone 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 sandstone and gray or olive, decomposed shale to silty shale occur near the base and along with the red beds between, comprise the Washington Valley Member of Unit (Olsen, 1980). Gray beds contain fish, reptile, amphibian, and diagnostic plant fossils. Although exposed regionally, this member is not seen in outcrop in the map area. As much as 2 ft. of Felville gray shale has been thermally metamorphosed along the contact with the Preankness Basalt (Jp). Thickness of unit ranges from 450 to 483 ft. regionally, but thins to about 100 ft. in the map area. Levels of natural radioactivity measured from outcrops of reddish-brown sandstone and siltstone range from 11 to 14 Micro R/hr and have a mean of 12.5.
- 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 spheroidal to tubular gas-escape vesicles, some filled by zeolite minerals or calcite lined with pyrite, 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 volcanoclastic rock. Upper part of upper flow is locally pillowed; upper part has tabular flow structures. Middle flow is massive to columnar jointed. Lower flow is generally massive with widely spaced columnar joints and is pillowed near the top with the space between pillows filled with zeolite and pyrite. 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 3 to 7 Micro R/hr and have a mean of 6.
- Jps** 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, siltstone, shaly siltstone, silty mudstone, and mudstone. Reddish-brown sandstone and siltstone are thin- to medium-bedded, planar to cross-bedded, micaceous, and locally microcracked and ripple cross-laminated. Root casts and leaf casts are common. Shaly siltstone, silty mudstone, and mudstone are fine-grained, very thin- to thin-bedded, planar to ripple cross-laminated, locally fissile, tabular, and contain evaporite minerals. They form rhythmically thinning-upward sequences up to 15 ft. thick. As much as 2 ft. of unit have been thermally metamorphosed and locally mineralized with sulfides along the contact with the Orange Mountain Basalt (Jo). Unit is exposed only in the southeastern part of the map area. Thickness of unit ranges from 35 to 11,480 ft. but only about 3,480 ft. occur in the map area. Levels of natural radioactivity measured from outcrops of reddish-brown siltstone and silty