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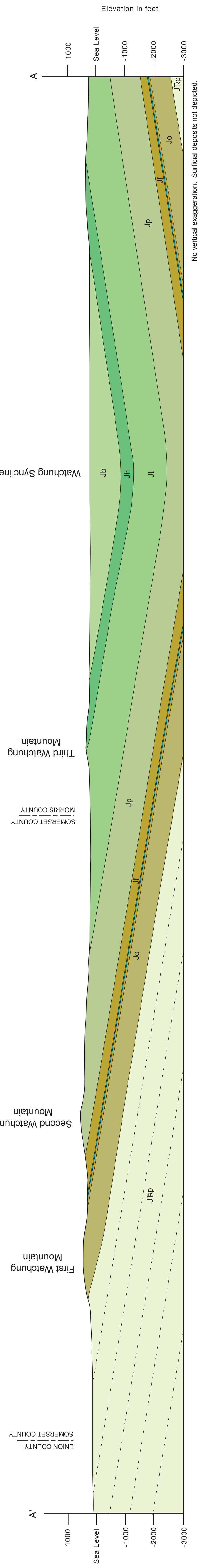

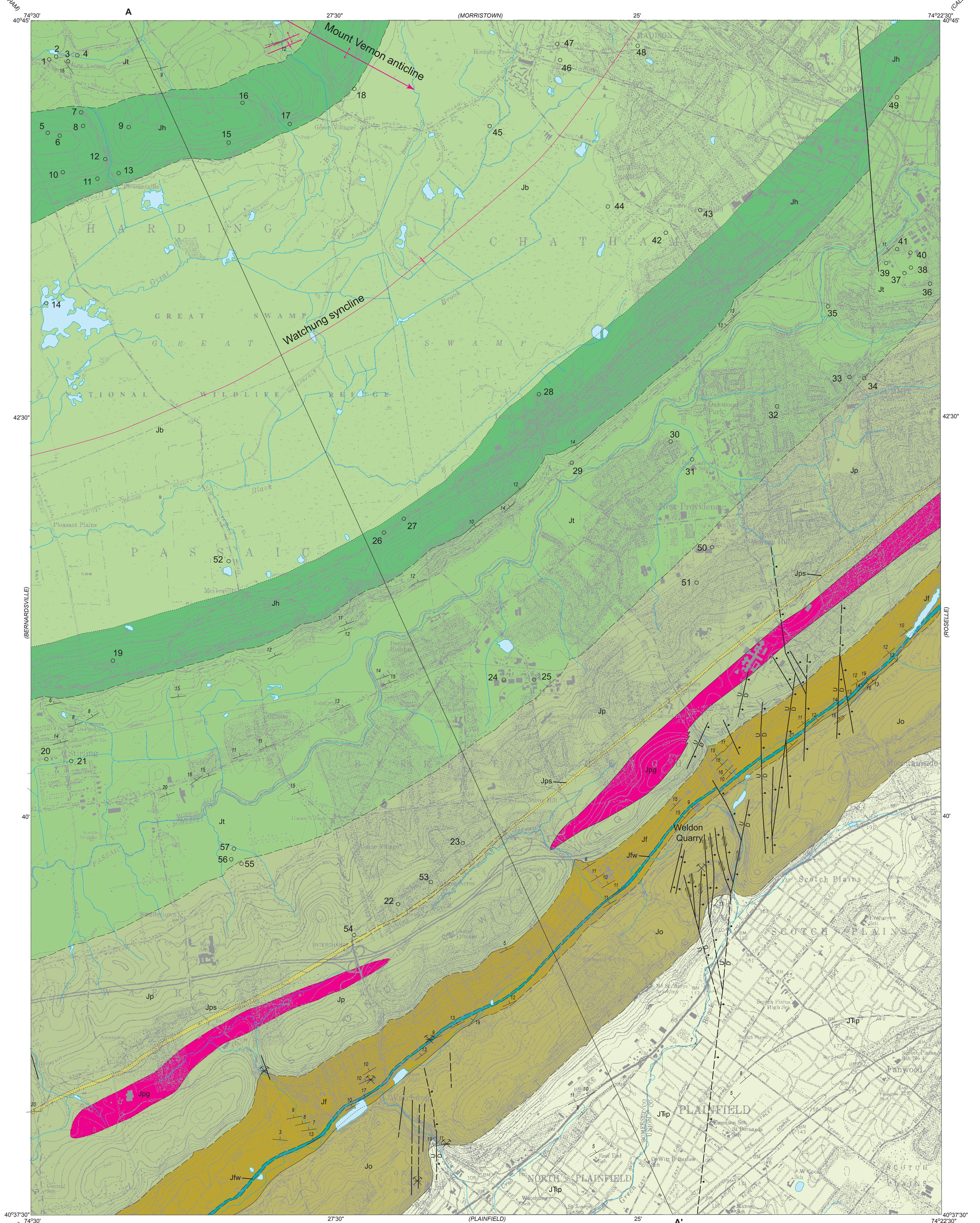

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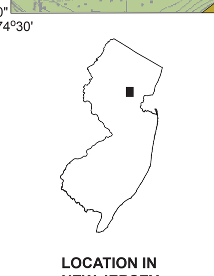
7000 FEET

1 KILOMETER



APPROXIMATE MEAN DECLINATION, 1961

Bedrock geology mapped by D.H. Monteverde and R.A. Volkert in 1999
Digital cartography by D.H. Monteverde
Reviewed by J. Puffer and L. Delclos

Bedrock Geologic Map of the Chatham Quadrangle
Morris, Somerset and Union Counties, New Jersey

By
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2005

INTRODUCTION

The Chatham 7.5-minute topographic quadrangle lies within the Piedmont Physiographic Province in north-central New Jersey. Somerset and Union Counties cover the southeastern half of the quadrangle and Morris County occupies the northwestern half. Development has been confined to the valleys and higher, more level topography. Recently, developers have begun the push towards the ridge slopes and crests. Interstate Route 78 provides easy access to industry and business centers to the east. The Great Swamp National Wildlife Refuge covering a large area in the north center of the quadrangle remains a large wildlife habitat amongst the developed regions of northern New Jersey.

The surficial and bedrock geology controls the varied topography in the quadrangle. Ridges underlain by igneous units delineate a strong northeast trend with elevations ranging from 400 to 560 feet above mean sea level. Sedimentary rocks mark the lower elevations from 90 to 220 feet between the igneous ridges. Glacial sediments that mute the bedrock geology form both the flat terrain of the Great Swamp and the slightly hummocky northwest trending topography northeast of the Great Swamp. Recent fluvial deposits from modern rivers are the latest features that shaped the current landscape of the quadrangle. Of these rivers the Passaic River is the largest and bisects the quadrangle along a northeast trend.

STRATIGRAPHY

Surficial cover dominates the geology of the Great Swamp National Wildlife refuge and the region to the northeast. These sediments consist of Pleistocene glacial units and Quaternary alluvial deposits. Glacial lake-bottom sediments control the flat lying Great Swamp topography (Salisbury and Kummel, 1895). The varied topography in the towns of Chatham and Madison marks the presence of the late Pleistocene terminal moraine (Stanford, unpublished data). Recent alluvial deposits mirror the trends of streams and rivers. A thin veneer of soil blankets the bedrock in the higher areas.

The bedrock units in this region developed in the Mesozoic during the initial breakup of the supercontinent of Pangea. Southeast-dipping normal faults controlled the formation of the Newark rift basin on the east. Continued episodic motion on these faults controlled the sediment input into the depression, both from the Highlands to the west and from an eastern source. Intrabasinal faulting was also active during deposition (Schlische, 1992, 1993). Bedrock units range from Early Jurassic to Late Triassic in age (Olsen, 1980a). They consist of a series of three basalt units separated by interbedded fluvial and lacustrine sediments. Each of the basalt units, from youngest to oldest the Hook Mountain, Preakness and Orange Mountain, consists of multiple flows. Van Houten (1969) described the internal structure common to many of the flows containing a lower and upper colonnade separated by an entablature zone. A basal massive basalt grading upward through a platy zone and into regular columns forms the lower colonnade. The entablature is the core of the flow and contains curvilinear columnar structures (Van Houten, 1969; Faust, 1978). The upper colonnade is marked by a lower pseudo-columnar zone capped by massive basalt and locally, scoria. The development of each of the three parts varies within the flows (Olsen, 1980a; Olsen and others, 1989). Pillow lavas are present locally (Van Houten, 1969). A thin sedimentary unit is mapped as part of the Preakness Basalt. Exposure of this unit in the quadrangle is sparse. Field notes from Henry Kummel (Kummel, 1900) located one area of outcrop where float chips of red-brown siltstone occur. A second locality within a new house foundation aided in delimiting the trend of the sediments. Evidence of the sedimentary layers also occurs in domestic well cuttings but its exact location in the eastern half of the quadrangle is problematic from the data gathered during this study.

The sedimentary units between the basalt formations portray a fluvial-to-lacustrine-deposition cyclicity. From oldest to youngest, they consist of the Passaic, Feltville, Towaco and Boonton formations. Units incorporate alternating, dominantly red-brown fluvial sediments, and gray to olive lacustrine deposits (Van Houten, 1969; Olsen, 1980a, 1980b; Olsen and others 1996). Fluvially deposited, sandstone through clayey siltstone to mudstone dominates over the siltstone to mudstone of lacustrine origin. Fedosh and Smoot (1988) suggested a lower fluvial gradient and deeper lake levels from the Passaic through the Feltville Formations deposition. Drier conditions persisted during the Towaco and Boonton Formation deposition. Olsen and others (1996) show Milankovitch orbital cyclicity controlling the fluvial- and lacustrine-sediment deposition. Gray bed cycles became important markers used in defining the various members of the sedimentary formations.

STRUCTURE

The Watchung syncline and Mount Vernon anticline, first outlined by Rogers (1840) are the major fold structures in the mapped area. Darton, (1890) first used the terms "Watchung flexure" and subsequently, Watchung syncline. Both limbs of the Watchung syncline dip gently, ranging from 6° to 15°. This produces a gentle broad open synclinal structure trending northeasterly. Pleistocene sediments blanket the fold axis but the trend of the axis parallels the trace of the Ramapo Fault in the region. The northwest-trending Mount Vernon anticline projects from the Morristown quadrangle into the northwest corner of the study area (Ratcliffe and others, 1990). Fold limbs of the anticline also dip at gentle angles, producing a gentle open fold.

A series of north-trending normal faults, marking the termination of the New Brunswick Fault, cuts the Orange Mountain and Preakness Basalts and the Passaic and Feltville Formations. The New Brunswick Fault traverses the Plainfield and New Brunswick quadrangles before losing displacement and splaying out into a myriad of smaller faults. Excellent examples of the normal faults occur within the Weldon Quarry. Limited subsidiary small normal faults can be found along the Passaic Formation/Orange Mountain Basalt front.

Figure 1 shows strike of bedding and fracture trends mapped and analyzed in 1999. Bedding partings were not classified as fractures but used to delineate strike of sedimentary units. Fractures within the sedimentary and igneous units cluster around due North and are not parallel to bedding trends.

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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 fining-upward sequences mostly 5 to 13 ft. thick. Red, gray, and brownish-purple siltstone and black, blocky, partly dolomitic siltstone and shale are common in the lower part of unit. Irregular mudcracks, symmetrical ripple marks, hummocky and trough cross-laminated, burrows, and evaporite minerals are abundant in red siltstone and mudstone. Gray, fine-grained sandstone may have carbonized plant remains and reptile footprints in middle and upper parts of unit. Maximum thickness 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 to large vesicles lined with prehnite and spherical to tubular gas-escape vesicles, some filled by zeolite minerals or calcite, typically above flow contacts. Unit consists of at least two, and possibly as many as three major flows. Base of lowest flow is intensely vesiculated. Tops of flows are weathered and vesiculated. Maximum thickness is about 360 ft.

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 grains, dinosaur tracks and fish fossils. Irregular mudcracks, symmetrical ripple marks present. Sandstone is commonly hummocky and trough cross-laminated and siltstone is commonly planar-laminated or bioturbated and indistinctly laminated to massive. Several inches of unit have been thermally metamorphosed along contact with Hook Mountain Basalt. Maximum thickness is about 1,250 ft.

Jp, Jpg, Jps — Preakness Basalt (Lower Jurassic) (Olsen, 1980a) - Dark-greenish-gray to black, fine-grained, dense, hard basalt composed mainly of intergrown plagioclase and clinopyroxene. Contains small tubular gas-escape vesicles, some filled by zeolite minerals or calcite, near the base of flows. Dark-gray, coarse- to very-coarse-grained gabbroid (Jpg) 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 in the unit. Their upper contacts are sharp and lower contacts are gradational with more typical finer-grained basalt. Unit consists of at least three major flows, the tops of which are marked by prominent vesiculated 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 thin, 6 to 25 ft.- thick bed of reddish-brown siltstone (Jps) separates the lower flows. Maximum thickness of unit is about 1,040 ft.

Jf, Jfw — 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. Reddish-brown sandstone and siltstone are moderately well sorted, commonly cross-laminated, and interbedded with reddish-brown, planar-laminated silty mudstone to mudstone. Two thin, laterally continuous sequences, each as much as 10 ft. thick , consisting of dark-gray to black, carbonaceous limestone, light-gray limestone, and medium-gray calcareous siltstone, and gray or olive, desiccated shale to silty shale occur near the base, and together with the red beds below, comprise the Washington Valley Member (Jfw) of Olsen (1980b). Gray beds may contain fish, reptiles, arthropods, and diagnostic plant fossils. Several inches of unit have been thermally metamorphosed along contact with Preakness Basalt (Jp). Thickness ranges from 450 to 483 ft.

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 small tubular gas-escape vesicles, some filled by zeolite minerals or calcite, and small to large vesicles lined with prehnite 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 copper-silfide-bearing, reddish-brown siltstone, or by volcaniclastic rock. Upper part of flows marked by olive-green hydrothermally altered horizon. Lower part of upper flow is locally pillowed; upper part has pahoehoe flow structure. Middle flow is massive to columnar jointed. Lower flow is generally massive with widely spaced curvilinear joints and is pillowed near the top. Individual flow contacts characterized by vesiculated zones as much as 8 ft thick. Reactivated lava tubes occur around pillow structures. Thickness of unit is about 715 ft.

JTRp — Passaic Formation (Lower Jurassic and Upper Triassic) (Olsen, 1980a) - Interbedded sequence of reddish-brown, and less commonly 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 mudcracked and ripple cross-laminated. Root casts and load casts are common. Shaly siltstone, silty mudstone, and mudstone are fine-grained, very thin to thin-bedded, planar to ripple cross-laminated, locally fissile, bioturbated, and contain evaporite minerals. They form rhythmically fining-upward sequences as much as 15 ft. thick. Several inches of unit have been thermally metamorphosed and locally mineralized with copper sulfides along contact with Orange Mountain Basalt (Jo). Unit is barely exposed in southwestern part of the map area, but regionally is as much as 11,480 ft. thick.

EXPLANATION OF MAP SYMBOLS

Contact - Dashed where approximately located; dotted where concealed; queried where uncertain

Faults - U, upthrown side; D, downthrown side. Ball shows direction of dip
Dashed where approximately located
Fault - High-angle fault of unknown movement

Fold axes - Showing trace of axial surface, direction and dip of limbs
Syncline - Showing troughline
Anticline - Showing crestline

Planar features

11 — Strike and dip of inclined beds

Other features

35 — Drill hole locations listed in Table 1

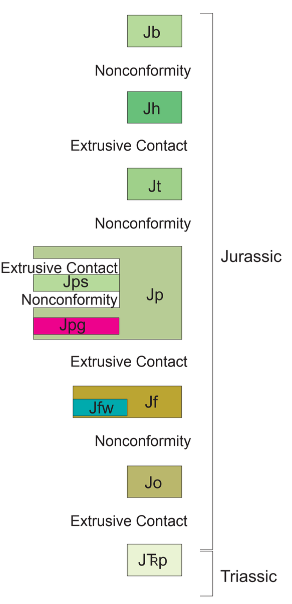
Abandoned rock quarry

Active rock quarry

Table 1. Well information from New Jersey Department of Environmental Protection well permit database.

Well Number	Well Permit Number	Depth (ft below grade)	Driller's Log
1	25-23739	0-4	overburden
		4-340	argillite, gray
2	25-20475	0-370	red shale
3	25-24588	0-5	overburden
		5-200	shale
4	25-16110	0-10	shale
		10-20	gray shale
		20-179	red & gray shale
5	25-20041	0-12	overburden
		12-120	red shale
		120-195	gray limestone
		195-248	red shale
6	25-22614	0-15	overburden
		15-70	red shale
		70-105	gray shale
		105-190	red sandstone
7	25-20227	0-12	overburden
		12-99	red shale
8	25-20305	0-12	overburden
		12-85	trap rock
		85-174	red rock & shale
9	25-17119	0-195	trap rock/baked shale contact
		195-385	baked shale/sandstone contact
10	25-20307	0-13	overburden
		13-198	trap rock
11	25-25559	0-8	overburden
		8-170	trap rock
		170-348	layers of red & gray shale
12	25-25075	0-40	broken rock
		40-140	trap rock
13	25-23904	0-10	overburden
		10-40	fractured granite
		40-194	granite
		194-250	red rock
14	90-00136	0-66.5	overburden
		66.5-67	brown decomposed shale
15	25-25283	0-15	overburden
		15-30	broken trap
		30-130	hard trap rock
16	25-25037	0-15	overburden
		15-210	red shale
17	25-06838	0-21	overburden
		21-30	soft trap rock
		30-77.6	hard trap rock
18	25-19602	0-140	sandstone
19	25-26235	0-30	overburden
		30-170	hard trap rock
		170-195	red shale
20	25-20337	0-30	overburden
		30-145	red shale
21	25-10198	0-56	clay
		56-81	red shale
		81-96	sandstone
22	25-00842	0-56	overburden
		56-130	fairly soft rock grading into harder rock,cuttings had a granite appearance at depth
23	25-00180	0-3	overburden
		3-24	trap rock
		24-283	mountain rock & trap
24	25-17255	0-15	overburden
		15-135	baked shale
		135-285	trap rock
25	25-13238	0-70	overburden
		70-150	red rock
		150-195	trap rock (very rotten last 10 ft)
26	25-10269	0-22	rotten rock
		22-120	basalt rock
27	25-10194	0-12	overburden
		12-35	trap rock
		35-130	trap rock
28	25-19177	0-40	overburden
		40-85	basalt
29	25-10363	0-80	decomposed shale & rock
		80-151	red rock
30	25-00485	0-132	overburden
		132-137	red sandstone rock
31	25-10530	0-72	overburden
		72-300	red shale
32	25-03271	0-125	overburden
		125-155	red sandstone
33	90-00113	0-223	overburden
		223-512	red rock
34	25-05068	0-186	overburden
		186-190	broken rock (dark gray basalt fragments with moderate amount of calcite)
		190-348	trap rock
35	25-03353	0-135	overburden
		135-145	red rock
36	25-08476	0-207	overburden
		207-241	red shale
		241-259	blue shale
		259-378	red shale
		378-434	red rock
		434-624	blue rock
		624-642	trap rock
37	25-08681	0-203	overburden
		203-410	red rock
		410-425	blue rock
		425-635	red rock
		635-800	blue rock
		800-838	trap rock
38	25-07298	0-196	overburden
		196-335	red rock
		355-375	gray rock
		375-503	red rock
		503-585	red, gray rock
		585-710	gray rock
		710-719	hard trap rock
39	25-33784	0-25	overburden
		25-48	brown sandstone
		48-52	gray sandstone
		52-68	reddish sandstone
		68-76	no drilling record
		76-85	gray-medium
		85-140	brown medium
		140-205	gray
		205-550	brown & gray
		550-760	brown & gray streaks
40	25-03786	0-200	overburden
		200-430	red rock
		430-475	gray rock
		475-623	red rock
41	25-00354	0-19	overburden
		19-74	red rock
		74-133	gray rock
		133-595	red rock
		595-610	gray rock
		610-729	red rock
42	25-00534	0-136	overburden
		136-146	hard gray shale
		146-158	hard gray and red shale
		158-187	hard red shale (some gray)
		187-195	shale, hard gray & red shale
		195-220	hard gray & red, partly limy shale
		220-238	hard red shale with hematite bedding planes
43	25-15137	0-225	overburden
		225-247	red slate to gray trap rock
		247-250	water seam
		250-293	hard gray trap rock/gray trap rock
44	90-00084	0-135	overburden
		135-150	shale, weathered on top
45	90-00085	0-160	overburden
		160-165	weathered shale
46	25-21429	0-230	overburden
		230-260	red shale
		260-300	red shale
47	25-13396	0-260	overburden
		260-280	gray rock
		280-350	red rock, some soft, clayey
		350-370	soft red rock
		370-410	harder red rock
		410-420	red gumbo
48	90-00086	0-220	overburden
		220	shale
49	25-14164	0-191	overburden
		191-193	sandstone, red/brown, unweathered
		193-197	shale, red/brown, unweathered
50	25-09823	0-19	clay & broken rock
		19-207	trap rock
51	25-10333	0-20	clay
		20-30	soft trap rock
		30-200	trap rock
52	25-09160	0-90	clay
		90-135	red shale
		135-158	gray rock
		158-200	red rock
53	25-31951	0-35	clay
		35-96	red shale
		96-123	trap rock
54	note from H.B. Kummel (1900)	at 28	encountered red shale
55	25-584803	0-24	surficial cover
		24-107	basalt
56	25-54817	0-18	cover
		18-34	gray siltstone
		34-44	dark reddish gray siltstone
		44-60	dark gray siltstone
		60-62	reddish gray siltstone
		62-64	gray siltstone
		64-117	basalt
57	25-54806	0-22	cover
		22-43	reddish brown silty sand + small gravel (decomposed Towaco)
		43-56	gray siltstone,
		56-58	reddish brown siltstone
		58-75	greenish gray siltstone
		75-78	reddish brown siltstone
		78-80	greenish gray siltstone
		80-82	reddish brown siltstone
		82-83	greenish gray siltstone
		83-107	basalt

CORRELATION OF MAP UNITS



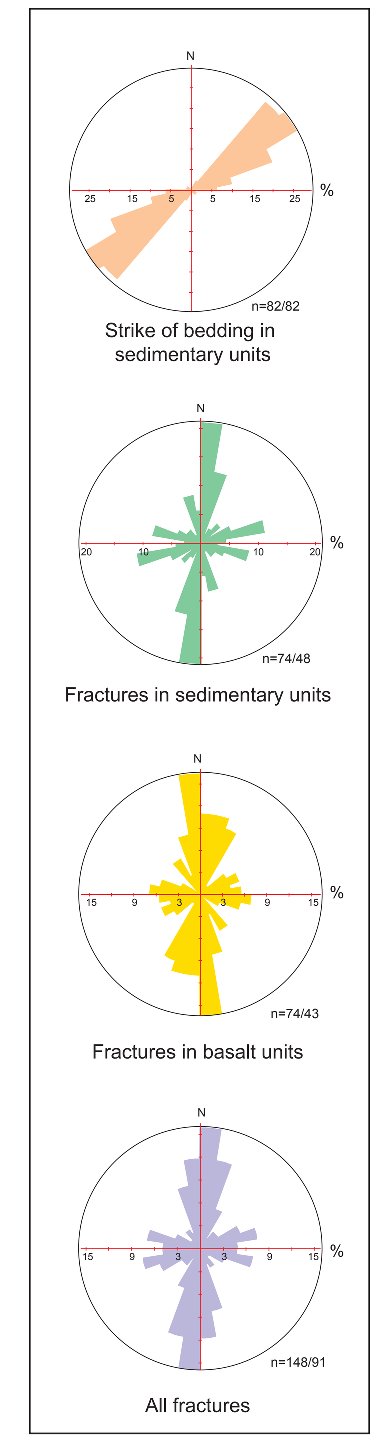


Figure 1. Bedding and fracture trends measured in outcrop. (n=number of readings/number of stations)