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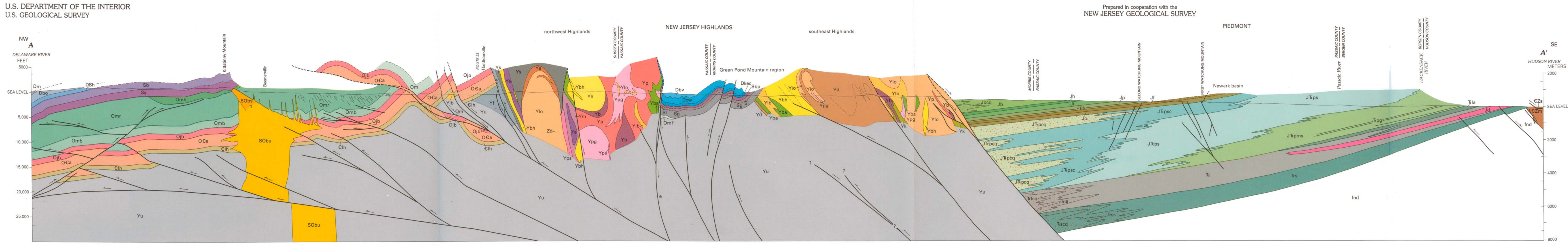

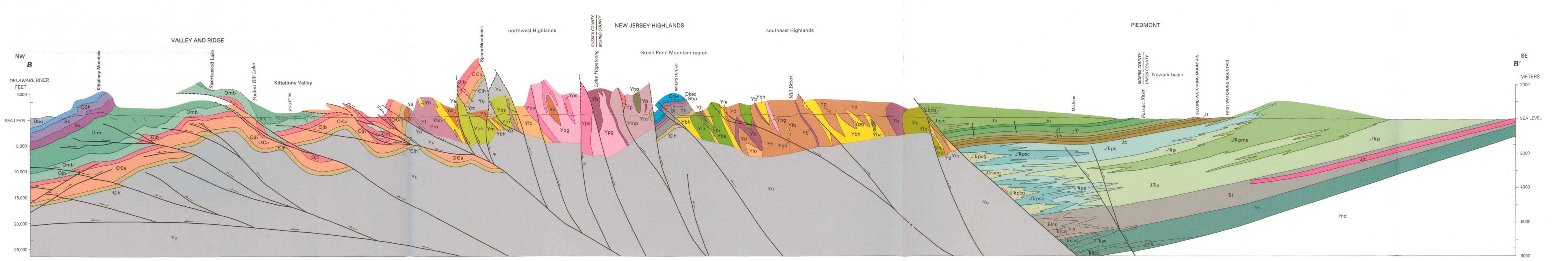

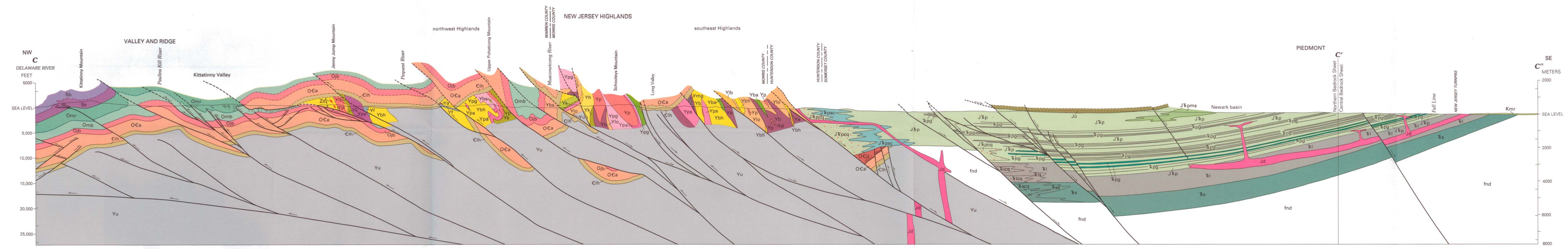

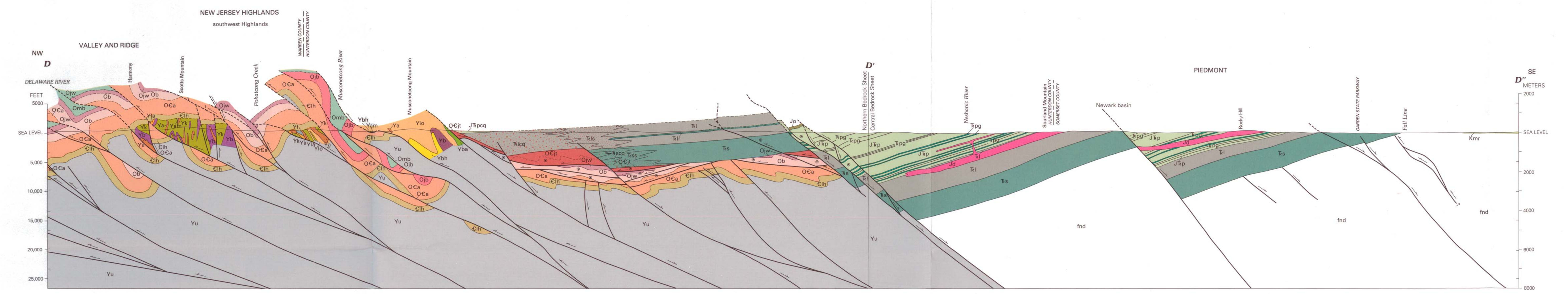

Cross sections constructed by G.C. Herman

CROSS SECTIONS OF THE VALLEY AND RIDGE, HIGHLANDS, AND PIEDMONT GEOLOGIC PROVINCES, NORTHERN AND CENTRAL BEDROCK SHEETS, NEW JERSEY

By G.C. Herman, D.H. Monteverde, R.A. Volkert, H.F. Houghton, R.A. Parker, A.A. Drake, Jr., and R.F. Dalton

Bedrock within the Valley and Ridge, Highlands, and Piedmont geologic regions of New Jersey is depicted in the cross sections to a depth of 8 km (5 mi). The rocks here form a composite, northwest-thinning tectonic wedge formed during the Taconic and Alleghanian orogenies; this wedge was extended locally by subsequent Mesozoic deformation. The sole thrust fault, together with many subsidiary splay faults, forms an imbricate-fan thrust-fault system that may have inherited structural components from a Late Proterozoic rift system. From regional seismic reflection data, Herman (1992) has interpreted the sole thrust to be restricted almost entirely to the Middle Proterozoic basement rock. Similarly, the northwest-dipping reverse faults along the northwest boundary of the regional thrust system (sections *A–A′*, *B–B′*, and *C–C′*) also are rooted in Proterozoic basement, for they appear to coincide with disconformable acoustic domains identified from seismic reflection profiling (modified from Herman, 1992).

Proterozoic rocks form the basement for Paleozoic rocks within the Valley and Ridge Province and Highlands and may locally underlie rocks of the Newark basin through faulting. Proterozoic rock structures are projected from surface structures into section as much as 4 km (2.5 mi) up plunge. Foliation generally dips moderately to steeply southeast throughout the Highlands, and the profile fold geometry generally is closed, overturned, and has southeast-dipping axial surfaces. Proterozoic rocks have not been differentiated below projected structures.

Thrust sheets in the northeast part of the Highlands contain Proterozoic basement rocks adjacent to slivers of lower and middle Paleozoic cover rocks occurring in downdropped and transpressional fault blocks. The faults were probably active throughout Paleozoic orogenesis and were reactivated locally during the Mesozoic (Ratcliffe, 1980). Thrust sheets within the southwest part of the Highlands contain more lower Paleozoic rocks compared to those to the northeast, but lack middle Paleozoic rocks. Complex fold and thrust structures occur in the southwest region where basement and cover structures resulting from an early phase of deformation were deformed subsequently. Faults within the Highlands generally become more gently dipping and involve more Paleozoic rocks to the southwest. Cambrian and Ordovician rocks crop out in the Kittatinny Valley, in faulted valleys in the Highlands, as well as locally along the southeast border of the Highlands, where they are unconformably overlain by Mesozoic rocks of the Newark basin. Cambrian and Ordovician rocks typically occur as segmented fold pairs within imbricate thrust slices. Lower Paleozoic cover rocks typically occur in segmented synformal valleys in the southeast Highlands area and Green Pond Mountain region. Footwall fold sequences are interpreted to extend beneath thrust faults to a limited extent by restoration of plunging structures at the current erosion surface (Merchant and Teet, 1954; Herman and Monteverde, 1989). Proterozoic basement is arched into the core of lower Paleozoic anticlines by complex shear systems that are locally exposed at the surface (Monteverde and others, 1989). Positive magnetic anomalies correspond to these "blind" basement arches beneath cover anticlines within the Valley and Ridge Province (Herman and Monteverde, 1988, 1989). The Beekmantown Group, sequence at Wantage, and the Jacksonburg Limestone are combined into a single unit everywhere, except for the northwest part of section *D–D′* where increased thickness of the Jacksonburg Limestone allows further subdivision at this scale.

The Cambrian and Ordovician folds in the northwest foreland are generally gentle to open with normal to moderately inclined axial surfaces. Toward the southeast, interlimb angles become tighter, and axial surfaces generally become more gently inclined or recumbent. Folds are typically segmented and transported northwestward by thrust faults. Basement structures related to the early fold phase within the Highlands or Piedmont Provinces are not shown in cross section because the geometry of these early structures is not known. However, basement structure linked to cover folding is shown within the Valley and Ridge, where most of the deformation is attributed to Alleghanian tectonism. Estimated crustal shortening from tectonic translation strain in the Valley and Ridge and southwest Highlands ranges from 16 km (10 mi) in the southwest to 10 km (6 mi) in the northeast, excluding prethrust cover-folding and layer-parallel shortening penetrative strains (Herman and others, 1991).

Lower Paleozoic cover rocks depicted beneath the Newark basin were projected from outcrop along the southeast border of the Highlands. These rocks occur in imbricate overthrust sheets and were probably deformed during the Taconic orogeny. These structures show complex motion involving both top-to-the-northwest and northeast translation. The latter is out of the plane of section and may reflect original lateral-ramp geometry or subsequent folding and faulting due to tectonic overprinting.

The intrusive rocks of the Beemerville Intrusive Suite (Drake and Monteverde, 1992) stylized in section *A–A′* are interpreted from gravity and magnetic geophysical studies of Jagel (1990) and Ghatge and others (1992). Offset of the intrusive complex by the sole fault was made by restoration of the thrust system in the Valley and Ridge Province (Herman and Monteverde, 1989) and from cross sections of the Pocono plateau by Wood and Bergin (1970), Berg and others (1980), and Wilson and Shumacher (1988).

Silurian and Devonian rocks in the Valley and Ridge Province are separated from Middle and Upper Ordovician rocks by a small angular disconformity (Epstein and Epstein, 1969; Epstein and Lyttle, 1987). Silurian and Devonian rocks in the Green Pond Mountain region locally overlie Cambrian and Ordovician rocks, as well as Proterozoic basement. Exposed faults are rare in the northwest part of the Valley and Ridge, where much of the cover folding is attributed to lower splay faults that terminate in fault propagation structures. Faults are more commonly exposed in the Green Pond Mountain region where they dip at moderate to high angles to the southeast and northwest. Movement along the northwest-bounding fault system in the Green Pond Mountain region was complex and involved both dip-slip and strike-slip components (Herman and Mitchell, 1991; Herman and Volkert, in press).

Mesozoic rocks in the Newark basin occupy a faulted, half-graben basin. Strata generally dip gently northwest, but are folded locally into open troughs and arches. The coarser grained alluvial facies of the Passaic Formation in the northeast part of the basin grade southwestward into finer grained facies and gray lacustrine beds. This transition from coarser to finer facies of the Passaic Formation is shown in sections *A–A′* through *D–D′*, although the interfingering of the siltstone and mudstone facies with gray beds in section *C–C′* probably is more gradational than shown because outcrops in the northeast are scarce. Stratigraphic and profile thicknesses were determined from measurements made around the perimeter of the basin and in outcrops on the Hunterdon plateau.

The structure of the Newark basin becomes more complex southwestward, where intrabasinal fault systems segment the basin and the border-fault system steps to the foreland. Most faults in the Newark basin are dip slip, but the larger intrabasinal faults also have apparent right-lateral slip. Regional seismic reflection data (Ratcliffe and Costain, 1985; D'Angelo, 1985; and Costain and Coruh, 1989) and drilling records (Ratcliffe and others, 1986) indicate the apparent dip of the border fault and the large intrabasin faults below the surface. The Passaic Formation directly overlies Paleozoic cover rocks and the Proterozoic basement along the border fault system, especially where component faults step towards the foreland because fault growth and deposition were synchronous (Schlische, 1992).

Metamorphosed Late Proterozoic and Cambrian rocks of the Manhattan prong are poorly exposed southeast of the Newark basin and are shown along the southeastern edge of section *A–A′*. These rocks are structurally complex. A thin veneer of Cretaceous consolidated sediment unconformably caps the southeastern part of the Newark basin and is shown in sections *C–C′* and *D–D′* southeast of the Fall line (central sheet) where Coastal Plain sediments are deposited.

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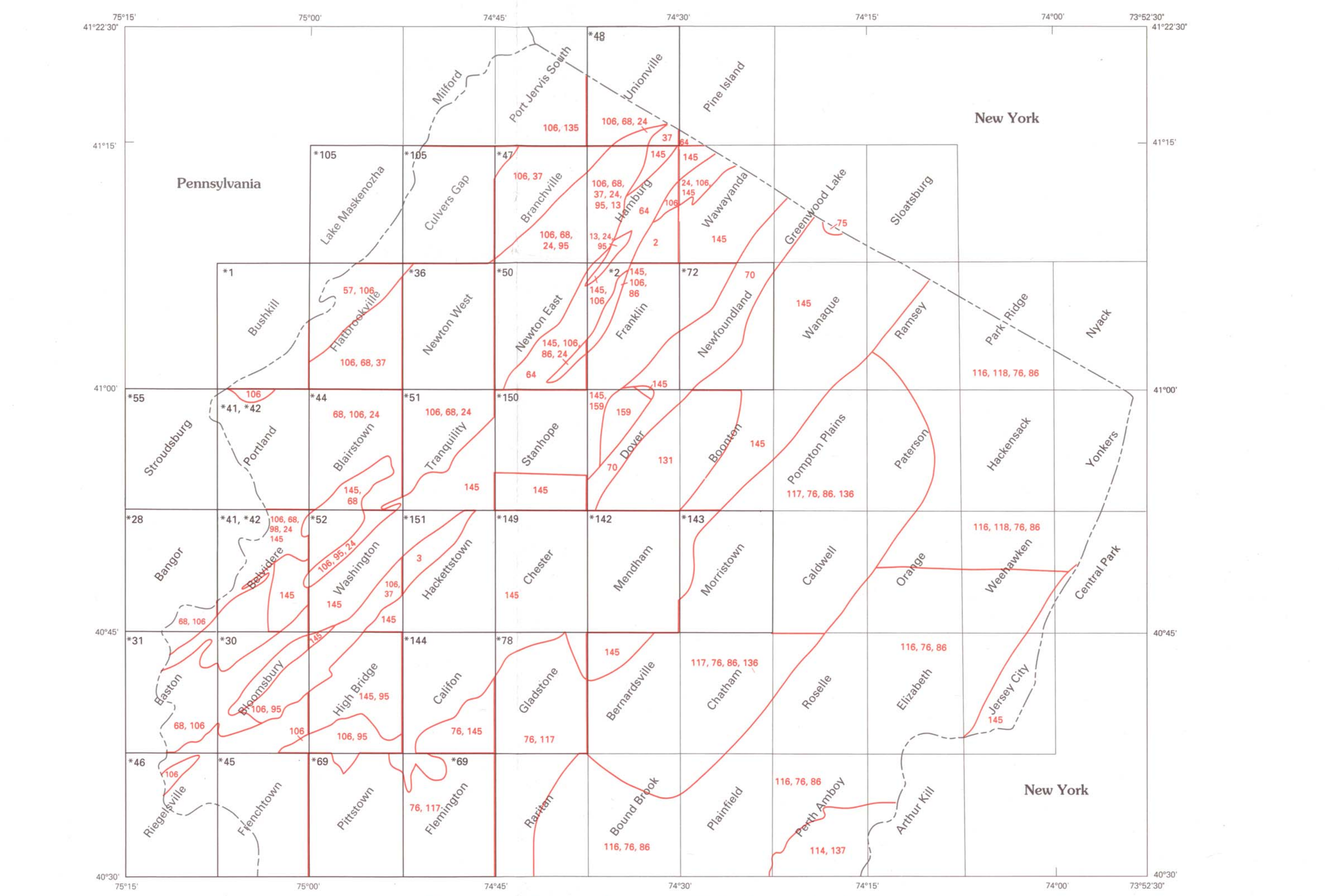

Index showing 7.5-minute topographic quadrangles and sources of bedrock data for northern New Jersey

(Numbers refer to entries in sources of geologic data; the more recent sources of data are listed first. Asterisk indicates geology published on quadrangle base at the scale of 1:24,000.)

VALLEY AND RIDGE PROVINCE

The Valley and Ridge Province of northwestern New Jersey (fig. 1) trends northeast and contains Lower Cambrian through Upper Ordovician rocks of the Kittatinny Valley sequence to the southeast and Lower Silurian through Middle Devonian rocks to the northwest. The Taconic unconformity separates the Middle and Upper Ordovician Martinsburg Formation from the Lower and Middle Silurian Shawangunk Formation along the base of Kittatinny Mountain. Cambrian and Ordovician rocks consist of basal clastics overlain by carbonates and a flysch to molasse clastic sequence. Above the Taconic unconformity, basal quartzite and conglomerate grade upward through interbedded sandstone and shale, interbedded carbonate and fine-grained clastics, and shale. These rocks were deformed principally during the Taconic and Alleghanian orogenies. Deformation generally decreases northwestward. Throughout the Valley and Ridge Province, folds are open to tight and upright, overturned, and gently inclined to recumbent. Within the Kittatinny Valley, gently dipping to high-angle faults commonly are exposed at the surface, whereas northwest of the Taconic unconformity, faults only locally are exposed at the present erosion surface

Dm **Marcellus Shale (Middle Devonian) (Vanuxem, 1840)**—Medium-gray-weathering, dark-gray to grayish-black, thin- to thick-bedded, fossiliferous, fissile and limonite-stained, locally arenaceous shale. Lower contact grades downward over 12 m (40 ft) from black shale through limy shale, into silty limestone of the Buttermilk Falls Limestone (documented in drill core data of Fletcher and Woodrow, 1970). Approximately 274 m (900 ft) thick

Dbo **Buttermilk Falls Limestone, Onondaga Limestone, Schoharie Formation, Esopus Formation, and Oriskany Group, undivided**—Shown in sections *A–A′* and *B–B′* only

Db **Buttermilk Falls and Onondaga Limestones, undivided (Middle Devonian)**—Buttermilk Falls Limestone in southwestern part of outcrop belt grades into Onondaga Limestone along strike to northeast. The transition occurs north of Millville

Buttermilk Falls Limestone (Willard, 1938)—Light- to medium-light-gray-weathering, medium- to dark-gray, thin- to medium-bedded, fossiliferous, flaggy, clayey to silty limestone and nodular black chert. Lower contact grades downward through several meters (feet) of silty limestone to interbedded limestone and calcareous siltstone of the Schoharie Formation. Thickness is approximately 82 m (270 ft)

Onondaga Limestone (Vanuxem, 1840)—Light-medium-gray-weathering, medium-gray, fine-grained, thin- to thick-bedded fossiliferous limestone. Black chert more abundant in upper half of unit. Lower contact grades into interbedded limestone and calcareous siltstone of the Schoharie Formation. Thickness approximately 60 m (200 ft)

Ds **Schoharie Formation (Lower Devonian) (Vanuxem, 1840)**—Yellowish-gray- to locally pale-olive-weathering, medium- to dark-gray, medium- to thick-bedded, calcareous siltstone and lesser amounts of silty limestone. Locally contains thin ribs or pods of black chert in limestone. Limestone content decreases in lower part of unit. Contains the trace fossil *Taonurus*, a grazing trail. Lower contact gradational and placed at top of highest massive siltstone below lowest limestone. Thickness approximately 53 m (175 ft)

De **Esopus Formation (Lower Devonian) (Vanuxem, 1842)**—Medium-gray-weathering, medium- to dark-gray, laminated to medium-bedded, partly massive, shaly to finely arenaceous siltstone, containing minor calcareous siltstone near top and, locally, limonite stains. Contains the trace fossil *Taonurus*. Rocks are cleaved in southwest and extreme northeast part of outcrop belt but not in central region. Lower contact sharp and unconformable with coarse quartz sandstone of the Oriskany Formation. Elsewhere, lower contact is conformable; fine sandstone to siltstone grades downward several meters to silty limestone. Thickness approximately 91 m (300 ft)

Do **Oriskany Group, undivided (Lower Devonian) (Willard, 1938)**— Thickness ranges from 38 m (125 ft) in southwest to 52 m (170 ft) in northeast

Ridgely Sandstone (Swartz and others, 1913)—White-weathering, medium-gray, medium- to thick-bedded, carbonate-cemented quartz-pebble conglomerate and coarse quartz sandstone, which contain abundant brachiopods. Moderately well sorted, subrounded sand grains. Unit thins northeastward and pinches out at Peters Valley. Lower contact abrupt. Thickness ranges from 0 to 10 m (0–32 ft)

Shriver Chert (Swartz and others, 1913)—Medium- to dark-gray-weathering, black to dark-gray, medium- to thick-bedded siltstone and shale containing interbedded black chert and local chert-bearing limestone. Present only in southwestern part of outcrop area where lower contact is gradational with silty limestone of Glenerie Formation. Thickness ranges from 0 to 9 m (0–30 ft)

Glenerie Formation (Chadwick, 1908)—Medium-gray-weathering, medium- to dark-gray, fine-grained, thin- to medium-bedded, fossiliferous, silty limestone, and local chert lenses. Unit thickens to northeast. Lower contact probably gradational. Thickness ranges from 17 to 52 m (55–170 ft)

Helderberg Group (Lower Devonian and Upper Silurian)

DSh **Helderberg Group (Port Ewen Shale, Minisink Limestone, New Scotland Formation, Kalkberg Limestone, Coeymans Limestone (Formation), and Manlius Limestone), Rondout Formation, Decker Formation, Bossardville Limestone, and Poxono Island Formation, undivided**—Shown in sections *A–A′*, *B–B′*, and *C–C′* only

Dp **Port Ewen Shale (Lower Devonian) (Clarke, 1903)**—Upper part is medium-gray-weathering, dark- to medium-dark-gray, thin- to medium-bedded, fossiliferous, calcareous siltstone and shale. Lower part is medium-dark-gray, irregularly bedded nonfossiliferous, calcareous silty shale. Lower contact abrupt and placed at top of uppermost medium-gray, argillaceous limestone in Minisink Limestone. Thickness approximately 46 m (150 ft)

Dmn **Minisink Limestone and New Scotland Formation, undivided (Lower Devonian)**

Minisink Limestone (Epstein and others, 1967)—Light-medium-gray-weathering, medium-gray, fine-grained, medium-bedded, partly massive, argillaceous fossiliferous limestone. Some nodules and lenses of purer limestone occur locally. Lower contact gradational. Thickness uniformly 7 m (23 ft)

New Scotland Formation (Clarke and Schuchert, 1899)—Upper part is dark-gray, very fine grained, laminated to thin-bedded siliceous shale containing pods of medium-dark-gray, very fine grained limestone; scattered thin beds and lenses of medium-gray, fine-grained argillaceous fossiliferous limestone; and small dark-gray chert nodules. Lower part is medium-dark-gray, thin-bedded, siliceous, fossiliferous calcareous shale. Contains thin beds and lenses of medium-gray, fine-grained, highly fossiliferous, argillaceous limestone containing nodules, lenses and, locally, irregular beds of dark-gray chert. Lower contact abrupt and placed at top of calcareous quartz sandstone. Total thickness is approximately 23 m (75 ft)

Dkc **Kalkberg Limestone, Coeymans Limestone, Manlius Limestone, and Coeymans Formation, undivided (Lower Devonian)**—At New York border consists of fine-grained, chert-bearing, argillaceous limestone (Kalkberg Limestone) grading downward through coarse-grained limestone (Coeymans Limestone) and fine-grained limestone (Manlius Limestone). Toward southwest these units grade into fine- to coarse-grained limestone with a marked increase in quartz sand that comprises the Coeymans Formation (Epstein and others, 1967). Total thickness 27 m (90 ft)

Kalkberg Limestone (Chadwick, 1908)—Medium-gray-weathering, medium-dark-gray, fine-grained, very thin to massively bedded fossiliferous limestone. Grades downward into fine- to medium-grained, thin-bedded, fossiliferous argillaceous limestone containing nodules and lenses of dark-gray chert. Grades to the southwest into calcareous and arenaceous rocks of the upper part of the Coeymans Formation near Wallpack Center. Lower contact placed at base of lowest black chert. Approximately 12 m (40 ft) thick

Coeymans Limestone (Clarke and Schuchert, 1899)—Medium-gray-weathering, medium-dark-gray, fine- to coarse-grained, medium- to massively bedded fossiliferous limestone and local argillaceous limestone lenses. Unit is approximately 9 m (30 ft) thick. Between Duttonville and Millville, grades into biohermal and nonbiohermal facies of medium- to coarse-grained limestone of Coeymans Formation of Epstein and others (1967).

Manlius Limestone (Vanuxem, 1840) — Medium-gray-weathering, medium-dark- to dark-gray, very fine to fine-grained, unevenly bedded, fossiliferous limestone. Some local medium-grained limestone, yellowish-gray shale partings, and biostromes. Near Hainesville, unit grades into lower part of Coeymans Formation. Lower contact abrupt and placed at top of uppermost very fine grained argillaceous limestone. Thickness approximately 11 m (35 ft)

Coeymans Formation (Epstein and others, 1967)—Medium-light-gray, fine- to coarse-grained calcareous sandstone and medium-gray, fine- to coarse-grained, medium- to thick-bedded, locally irregularly bedded, argillaceous to arenaceous limestone containing lenses of quartz sand and nodules of black chert. Grades downward into medium-gray, fine-grained, argillaceous and arenaceous limestone containing local beds of fine- to coarse-grained pebbly calcareous sandstone. Local bioherms consisting of light-gray to light-pinkish-gray, coarse-grained to very coarse biogenic limestone are unbedded and have sharp boundaries. Lower contact of unit abrupt. Formation thickness varies from 11 m (35 ft) in northeast to 24 m (80 ft) in southwest

DSrd **Rondout and Decker Formations, undivided (Lower Devonian and Upper Silurian)**

Rondout Formation (Lower Devonian and Upper Silurian) (Clarke and Schuchert, 1899)—Upper part is medium-gray-weathering, medium-dark-gray, very fine to fine-grained, medium-bedded, fossiliferous, argillaceous limestone. Middle part is light-medium-gray-weathering, medium-gray, laminated to medium-bedded, argillaceous dolomite. Locally contains deep desiccation polygons. Lower part is medium-gray-weathering, medium- to dark-gray, very fine to medium-grained, medium-bedded fossiliferous limestone. Silurian-Devonian boundary placed in middle of formation (Denkler and Harris, 1988). Lower contact abrupt and placed at top of highest calcareous quartz sandstone. Thickness approximately 12 m (40 ft)

Decker Formation (Upper Silurian) (White, 1882)—Light-gray- to yellowish-gray-weathering, light- to medium-gray, calcareous quartz siltstone, sandstone, and fine-pebble conglomerate locally interbedded with fossiliferous medium-gray, medium- to coarse-grained limestone and very fine grained, thin- to medium-bedded dolomite. Lower contact gradational. Thickness varies from 15 m (50 ft) near Duttonville to 25 m (82 ft) at Wallpack Center

Sbv **Bossardville Limestone (Upper Silurian) (White, 1882)**—Light-gray- to yellowish-gray-weathering, medium-gray to medium-dark-gray, very fine grained, locally fossiliferous, laminated to thin-bedded limestone and argillaceous limestone. Desiccation polygons occur in southwest. Lower contact is gradational and placed at top of uppermost dolomite. Thickness approximately 30 m (100 ft) in southwest, thinning to 3.1 m (10 ft) at New Jersey-New York State boundary

Sp **Poxono Island Formation (Upper Silurian) (White, 1882)**—Greenish-gray, finely crystalline to aphanitic, thin- to medium-bedded, flaggy dolomite containing discontinuous lenses of disseminated, rounded quartz grains. Some local quartz sandstone beds and argillaceous dolomite. Lower contact gradational (Epstein, 1973). Formation poorly exposed; located by drill data. Thickness estimated at 183 m (600 ft) from well data

Sb **Bloomsburg Red Beds (Upper Silurian) (White, 1883) (High Falls Shale of previous usage)**—Grayish-red, thin- to thick-bedded, poorly to moderately well sorted, massive siltstone, sandstone, and local quartz-pebble conglomerate containing local planar to trough crossbedded laminations. Conglomerate consists of matrix-supported quartz pebbles in grayish-red, fine-grained sandstone matrix. Locally, near base of unit, is greenish-gray, light-gray, or grayish-orange, massive, planar tabular to trough crossbedded quartz sandstone grading to siltstone with subrounded grains. Lower part of formation marked by several upward-fining sequences of light-gray sandstone grading through grayish-red, fine-grained sandstone and siltstone to grayish-red, mudcracked siltstone and mudstone. Each sequence is 1 to 3 m (3–10 ft) thick. Lower contact placed at bottom of lowermost red sandstone. Thickness approximately 460 m (1,510 ft)

Ss **Shawangunk Formation (Middle and Lower Silurian) (Mather, 1840; Epstein and Epstein, 1972)**—Upper part is medium- to medium-dark-gray, or dark-greenish-gray, medium- to thick-bedded sandstone and pebble conglomerate having well-rounded grains, some of which are limonite stained. Conglomerate consists of matrix-supported quartz and subordinate shale pebbles as long as 5 cm (2 in.) in poorly to well-sorted, planar tabular to trough crossbedded sandstone. Local black to dark-greenish-gray, thin-bedded shale near upper contact. Middle part, occurring in southwest and sporadically in northeast, is light- to medium-dark-gray, greenish-gray, interbedded thin- to medium-bedded, planar tabular to trough crossbedded shale and sandstone. Grains are well rounded and moderately to well sorted. Contains sparse graphite flakes. Lower part is light- to medium-gray to light-olive-gray, thin- to thick-bedded quartz and feldspathic sandstone, quartzite, and quartz-pebble conglomerate, which is matrix supported, poorly to well sorted, and cross to planar bedded. Clasts are primarily quartz and sparse dark-gray argillite and black chert. Sandstone is feldspathic and locally approaches an arkose in composition. Lower contact unconformable and, at places, is a fault of small displacement. Thickness approximately 427 m (1,400 ft)

Beemerville Intrusive Suite (Early Silurian? and Late Ordovician) (Drake and Monteverde, 1992)

SObu **Beemerville Intrusive Suite, undivided**—Shown in section *A–A′* only

SObs **Nepheline syenite**—Medium- to dark-gray, medium- to coarse-grained, alkalic to alkalic-calcic nepheline syenite. Composed principally of nepheline, orthoclase, biotite, and clinopyroxene, and accessory minerals are magnetite, apatite, titanite, zircon, and pyrite. Restricted to two small bodies northwest of Beemerville. Intrudes the Martinsburg Formation, but appears to be unconformably overlain by the Shawangunk Formation. K-Ar and Rb-Sr ages of 435±20 Ma from biotite (Zartman and others, 1967) and a fission track date from titanite of 422±14 Ma (Eby and others, 1992) suggest emplacement in Late Ordovician to Early Silurian

SObb **Ouachitite breccia**—Medium-dark-gray, fine-grained ouachitite (olivine-free biotite lamprophyre) containing pebble- to cobble-size xenoliths of Middle Proterozoic rock, dolomite of the Kittatinny Supergroup(?), the Martinsburg Formation, and autoliths of potassic syenite, lamprophyre, and carbonatite. Found in numerous diatremes in the Beemerville area; largest at Rutan Hill

SObl **Lamprophyre, tinguaite (phonolite with acicular acmite crystals), phonolite, bostonite (trachyte), and malignite (mafic nepheline syenite), undifferentiated**—Light-medium- to medium-dark-gray, aphanitic to fine-grained, alkalic to calcic-alkalic dikes and sills. Unit intrudes rocks from the Middle Proterozoic to the High Point Member of the Martinsburg Formation, but does not intrude the Shawangunk Formation. K-Ar date of 422±14 Ma from biotite phenocrysts in a minette (lamprophyre with biotite phenocrysts) dike (Charles Milton, written commun., 1972) suggests an Early Silurian age for some of these rocks

KITTATINNY VALLEY SEQUENCE

Rocks of Cambrian and Ordovician age within the Kittatinny Valley and valleys infaulted into the New Jersey Highlands are assigned to the Kittatinny Valley sequence (fig. 1). These rocks were previously ascribed to the Lehigh Valley sequence of MacLachlan (1979). The Kittatinny Valley sequence includes the carbonate and siliciclastic rocks of the Hardyston Quartzite and Kittatinny Supergroup, the localized clastic and carbonate rocks of the sequence at Wantage, the Jacksonburg Limestone, and the Martinsburg Formation. Principal differences between the Kittatinny Valley and Lehigh Valley sequences, northeast from Pennsylvania to New York are: 1) thinning of the Kittatinny Supergroup, 2) dominance of dolomite relative to limestone in the Kittatinny Supergroup, 3) thinning to total absence of the argillaceous facies of the Jacksonburg Limestone, and 4) thinning and coarsening of the Martinsburg Formation

Om **Martinsburg Formation, undivided (Upper and Middle Ordovician) (Bayley and others, 1914)**—Interbedded light-olive-gray-, greenish-gray-, or dark-yellowish-brown-weathering, medium-dark- to dark-gray, laminated to medium-bedded graywacke and siltstone and olive-gray- to dark-yellowish-brown-weathering, medium-dark- to dark-gray slate. Turbidite cycles are common. Mapped only east of Lafayette and west of Lake Grinnell where thickness is at least 305 m (1,000 ft)

Omh High Point Member (Upper Ordovician) (Drake, 1991)—Medium-dark-gray, thin-bedded shale, siltstone, and fine-grained sandstone containing turbidite sequences T_{bcde} to T_{cde} of Bouma (1962). Interbedded with less abundant, light-yellowish-gray-weathering, medium-gray to medium-dark-gray, medium-grained, medium- to thick-bedded and massive, quartz- and calcareous-cemented quartz sandstone that commonly contains rip-ups of medium- to dark-gray shale and siltstone that commonly consist of Bouma (1962) turbidite sequences T_{ab} to T_a. Restricted to northwest section of Martinsburg outcrop belt. Thermally metamorphosed near intrusive bodies. Grades along strike to the southwest into Ramseyburg Member by decrease in average grain size, absence of shale rip-ups, and lack of siliceous cement. Lower contact gradational and placed at base of lowermost thick-bedded graywacke or amalgamated graywacke containing shale rip-ups. Unit assigned to *Orthograptus ruedemanni* zone to *Climacograptus spiniferus* zone of Riva (1969, 1974) using graptolites collected by Parris and Cruikshank (1992). Thickness ranges from 0 to 1,370 m (0–4,500 ft)

Omr Ramseyburg Member (Upper and Middle Ordovician) (Drake and Epstein, 1967)—Interbedded medium- to dark-gray to brownish-gray, fine- to medium-grained, thin- to thick-bedded graywacke sandstone and siltstone and medium- to dark-gray, laminated to thin-bedded shale and slate. Unit may form complete turbidite sequences, T_{abcde} (Bouma, 1962), but basal cutout sequences T_{cde} dominate. Basal scour, sole marks, and soft-sediment distortion of beds are common in graywacke. Thermally metamorphosed near intrusive bodies. Lower contact placed at bottom of lowest thick- to very thick bedded graywacke, but contact locally grades through sequence of dominantly thin-bedded shale and slate and minor thin- to medium-bedded, discontinuous and lenticular graywacke beds in the Bushkill Member. Parris and Cruikshank (1992) correlate unit with *Orthograptus ruedemanni* to lowest part of *Climacograptus spiniferus* zones of Riva (1969, 1974). Thickness ranges from 640 m (2,100 ft) in Delaware River Valley, to 1,524 m (5,000 ft) near Stillwater, to 1,067 m (3,500 ft) at New York State line

Omb Bushkill Member (Middle Ordovician) (Drake and Epstein, 1967)—Interbedded medium- to dark-gray, thinly laminated to thick-bedded shale and slate and less abundant medium-gray to brownish-gray, laminated to thin-bedded siltstone. To the southwest, fine-grained, thin dolomite lenses occur near base. Complete turbidite sequences (Bouma, 1962) occur locally, but basal cutout sequences (T_{bcde}, T_{cde}, or T_{de}) dominate. Conformable lower contact is placed at top of highest shaly limestone; elsewhere, lower contact is commonly strain slipped. Correlates with graptolite *Climacograptus bicornis* to *Corynoides americanus* zones of Riva (1969, 1974) (Parris and Cruikshank, 1992). Thickness ranges from 1,250 m (4,100 ft) in Delaware River Valley to 457 m (1,500 ft) at New York State line

Ojb **Jacksonburg Limestone, sequence at Wantage, and Beekmantown Group, undivided**—Shown in sections *A–A′* through *D–D′* only

Ojw **Jacksonburg Limestone and sequence at Wantage, undivided**—Shown in section *D–D′* only

Oj **Jacksonburg Limestone (Middle Ordovician) (Kümmel, 1908; Miller, 1937)**—Upper part is medium- to dark-gray, laminated to thin-bedded shaly limestone and less abundant medium-gray arenaceous limestone containing quartz-sand lenses. Upper part thin to absent to northeast. Lower part is interbedded medium- to dark-gray, fine- to medium-grained, very thin to medium-bedded fossiliferous limestone and minor medium- to thick-bedded dolomite-cobble conglomerate having a limestone matrix. Unconformable on Beekmantown Group and conformable on the discontinuous sequence at Wantage in the Paulins Kill area. Contains conodonts of North American midcontinent province from *Phragmodus undatus* to *Aphelognathus shatzeri* zones of Sweet and Bergstrom (1986). Thickness ranges from 41 to 244 m (135–800 ft)

Ow **Sequence at Wantage (Middle Ordovician) (Monteverde and Herman, 1989)**—Restricted, discontinuous sequence of interbedded limestone, dolomite, conglomerate, siltstone, and shale. Upper part is medium-yellowish-brown- to olive-gray-weathering, medium- to dark-gray, very fine to fine-grained, laminated to massive limestone and dolomite that grade down into underlying clastic rocks of lower part. Upper part locally absent. Lower part ranges from grayish-red, medium-gray, pale-brown, and greenish-gray to pale-green mudstone and siltstone containing disseminated subangular to subrounded chert-gravel, quartz-sand lenses, and chert-pebble conglomerate. Lower contact unconformable. Thickness ranges from 0 to 46 m (0–150 ft)

Kittatinny Supergroup (Lower Ordovician and Cambrian) (Drake and Lyttle, 1980)

Beekmantown Group (Lower Ordovician) (Clarke and Schuchert, 1899)—See figure 2 for correlation with previous nomenclature

Ob **Beekmantown Group, undivided**—Shown in section *D–D′* only

Obu **Upper part**—Locally preserved upper beds are light- to medium-gray- to yellowish-gray-weathering, medium-light- to medium-gray, aphanitic to medium-grained, thin- to thick-bedded, locally laminated, slightly fetid dolomite. Medium-dark to dark-gray, fine-grained, medium-bedded, sparsely fossiliferous limestone lenses occur locally. Lower beds are medium-dark- to dark-gray, medium- to coarse-grained, mottled surface weathering, medium- to thick-bedded, strongly fetid dolomite that contains pods and lenses of dark-gray to black chert. Cauliflower-textured black chert beds of variable thickness occur locally. Gradational lower contact is placed at top of laminated to thin-bedded dolomite of the lower part (Obl) of the Beekmantown Group. Contains conodonts high in the *Rossodus manitouensis* zone to low zone D of the North American midcontinent province as used by Sweet and Bergstrom (1986). Upper beds are included in Epler Formation; lower beds are included in Rickenbach Dolomite of Drake and Lyttle (1985) and Drake and others (1985); entire upper part (Obu) is Ontelaunee Formation of Markewicz and Dalton (1977) (fig. 2). Thickness ranges from 0 to 244 m (0–800 ft)

Obl **Lower part**—Very thin to thick-bedded, interbedded dolomite and minor limestone. Upper beds are light-olive-gray to dark-gray, fine- to medium-grained, thin- to thick-bedded dolomite. Middle part is olive-gray-, light-brown-, or dark-yellowish-orange-weathering, dark-gray, aphanitic to fine-grained, laminated to medium-bedded dolomite and light-gray- to light-bluish-gray-weathering, medium-dark- to dark-gray, fine-grained, thin- to medium-bedded limestone that is characterized by mottling due to reticulate dolomite and light-olive-gray to grayish-orange, dolomitic shale laminae surrounding limestone lenses. Limestone grades laterally and down section into medium-gray, fine-grained dolomite. Lower beds consist of medium-light- to dark-gray, aphanitic to coarse-grained, laminated to medium-bedded, locally slightly fetid dolomite having thin black chert beds, quartz-sand laminae, and oolites. Lenses of light-gray, very coarse to coarse-grained dolomite and floating quartz-sand grains and quartz-sand stringers at base of sequence. Lower contact placed at top of distinctive medium-gray quartzite. Contains conodonts of *Cordylodus proavus* to *Rossodus manitouensis* zones of North American midcontinent province as used by Sweet and Bergstrom (1986). Unit Obl forms Stonehenge Formation of Drake and Lyttle (1985) and Drake and others (1985), upper and middle beds are included in Epler Formation, and lower beds are in Rickenbach Dolomite of Markewicz and Dalton (1977) (fig. 2). Unit is about 183 m (600 ft) thick

O€a **Allentown Dolomite (Lower Ordovician and Upper Cambrian) (Wherry, 1909)**—Very thin to very thick bedded dolomite containing minor orthoquartzite and shale. Upper part is medium-light- to medium-dark-gray, fine- to medium-grained, locally coarse-grained, medium- to very thick bedded dolomite. Floating quartz-sand grains and two sequences of medium-light- to very light gray, thin-bedded quartzite and discontinuous, dark-gray chert lenses occur directly below upper contact. Rhythmically bedded lower dolomite beds alternate between light and dark gray weathering, medium and very light gray, fine and medium grained, and thin and medium bedded, which are interbedded with shaly dolomite. Ripple marks, crossbeds, edgewise conglomerate, mud cracks, oolites, and algal stromatolites occur throughout unit, but more typically in lower part. Shaly dolomite increases downward toward lower conformable contact with the Leithsville Formation. Oldest beds contain trilobite fauna of early Late Cambrian age; younger beds contain latest Cambrian fauna (Howell, 1945; Howell and others, 1950). Thickness about 580 m (1,900 ft)

€lh **Leithsville Formation and Hardyston Quartzite, undivided**—Shown in sections *A–A′* through *D–D′* only

€l **Leithsville Formation (Middle and Lower Cambrian) (Wherry, 1909)**—Thin- to thick-bedded dolomite containing subordinate siliciclastic rocks. Upper part is medium- to medium-dark-gray, fine- to medium-grained, pitted, friable, mottled and massive dolomite. Middle part is medium-gray, stylolitic, fine-grained, thin- to medium-bedded dolomite that is interbedded with shaly dolomite and, less commonly, varicolored quartz sandstone, siltstone, and shale. Lower part is medium-gray, medium-grained, medium-bedded dolomite containing quartz-sand grains in stringers and lenses near the contact with the Hardyston Quartzite. Archaeocyathids of Early Cambrian age suggest an intraformational disconformity separating rocks of Middle and Early Cambrian age (Palmer and Rozanov, 1976). Thickness approximately 305 m (1,000 ft)

€h **Hardyston Quartzite (Lower Cambrian) (Wolff and Brooks, 1898)**—Medium- to light-gray, fine- to coarse-grained, medium- to thick-bedded quartzite, arkosic sandstone, and dolomitic sandstone. Basal pebble to cobble conglomerate typically contains clasts of local basement affinities. Contains fragments of the trilobite *Olenellus thompsoni* of Early Cambrian age. Thickness ranges from 0.5 to 62 m (1.6–200 ft)

JUTLAND KLIPPE SEQUENCE

Rocks of the Jutland klippe sequence occur in six isolated fragments of the Jutland klippe east of Jutland and two fragments of the Peapack klippe along the Peapack-Ralston fault in the New Jersey Highlands hinterland (fig. 1). The sequence is largely varicolored shale and sandstone, but contains lesser amounts of limestone, dolomite, and pebble conglomerate. Lash and Drake (1984) correlate this sequence with the accretionary prism deposits of the Greenwich slice of the Hamburg klippe in eastern Pennsylvania. Rocks of the Jutland klippe sequence were folded and thrust over rocks of the Kittatinny Valley sequence during the Taconic orogeny and then were deformed during the Alleghanian orogeny and again during Mesozoic rifting of eastern North America

O€jt **Rocks of the Jutland klippe sequence, undifferentiated (Middle Ordovician to Upper Cambrian?)**

Ojtb **Unit B of Perissoratis and others (1979) (Middle Ordovician)**—Heterogeneous sequence of interbedded red, green, tan, and gray shale; interlaminated dolomite and shale; interbedded fine-grained graywacke, siltstone, and beds or lenses of sandstone; light-gray to pale-pinkish-gray quartzite; and interbedded fine-grained, thin-bedded limestone and red and green shale. Limestone locally resembles an intraformational conglomerate because it is disrupted, boudinaged, and surrounded by shale beds. Lower contact gradational and within interbedded sequence of thin- to medium-bedded sandstone, siltstone, and limestone. Perissoratis and others (1979) placed this contact at the boundary between graptolite faunas *Isograptus caduceus* and *Paraglossograptus etheridgei* of Berry (1968). The youngest graptolites occur within the *Climacograptus bicornis* zone of Berry (1968). Some shale beds contain conodonts (Ethington and others, 1958; Karklins and Repetski, 1989) and brachiopod fragments. Carbonate and pelitic rocks locally contain conodonts of *Prioniodus triangularis* to *Pygodus anserinus* faunas of North Atlantic Realm. Thickness varies due to structural complexity, but may be about 460 to 550 m (1,500–1,800 ft)

O€jta **Unit A of Perissoratis and others (1979) (Middle Ordovician to Upper Cambrian)**—Interbedded red, green, and tan shale, sandstone, and dark-gray, aphanitic to fine-grained limestone, which contains floating quartz-sand grains. Grades downward through interbedded sequence of red, green, and brown shale to medium-gray to brown, fine- to coarse-grained sandstone and quartz-pebble conglomerate. Lower beds are dark-gray shale and siltstone containing minor dark-gray, aphanitic to fine-grained, medium-bedded limestone. Lower contact is a fault. Contains graptolites in the span of *Anisograptus* to *Isograptus caduceus* of Berry (1968) (Perissoratis and others, 1979) and conodonts of the *Cordylodus proavus* to *Paroistodus proteus* faunas of the North Atlantic Realm. Thickness is unknown

MANHATTAN PRONG

€Zm **Manhattan Schist (Lower Cambrian and (or) Late Proterozoic) (Hall, in press)**—Medium-dark-gray, medium- to coarse-grained schist and gneiss composed of biotite, muscovite, quartz, and plagioclase, and local accessory minerals sillimanite, kyanite, tourmaline, and garnet. Contains some interlayered amphibolite. Unit not exposed in map area, but present in boring logs

€Zs **Serpentinite (Cambrian and Late Proterozoic)**—Light-yellowish-green to dark-green, fine-grained, massive serpentinite containing locally abundant magnetite where fresh. Contains a variety of serpentine minerals and alteration products where sheared or weathered. Exposed only along the Hudson waterfront in Hoboken but present elsewhere in boring logs

NEW JERSEY HIGHLANDS

Rocks of Middle and Late Proterozoic age occur in the New Jersey Highlands (fig. 1). Middle Proterozoic rocks consist of heterogeneous metasedimentary and metavolcanic gneisses and granofels intruded by the synkinematic Byram and Lake Hopatcong Intrusive Suites and the postkinematic Mount Eve Granite (fig. 3). The oldest rocks are plagioclase-rich gneiss and associated amphibolite of the Losee Metamorphic Suite, which is a metamorphosed sequence of dacite, quartz keratophyre, basalt, and intrusive tonalite and trondhjemite. They are associated with charnockitic gneisses and granulites that probably have a metavolcanic protolith. These rocks are unconformably overlain by quartz-feldspar gneisses of arkosic and graywacke composition, felsic volcanic rocks, quartzite, calc-silicate gneiss, and marble. Rocks of the Lake Hopatcong and Byram Intrusive Suites and the Mount Eve Granite intrude all of these lithologies. Middle Proterozoic rocks were regionally metamorphosed to upper amphibolite to hornblende granulite facies. The Late Proterozoic Chestnut Hill Formation is a weakly to nonmetamorphosed sequence of interbedded clastic, metavolcanic rocks, and metasaprolite locally preserved as erosional remnants and small slices along faults. Diabase dikes of probable Late Proterozoic age intrude all Middle Proterozoic rocks of the Highlands geologic province

Zd **Diabase dikes (Late Proterozoic) (Ratcliffe, 1987; Puffer and others, 1991)**—Medium- to dark-greenish-gray, aphanitic to fine-grained dikes that are dense and hard. Contacts are typically chilled and sharp against enclosing country rock. Tholeiitic to alkalic composition; hypersthene a normative mineral. Composed principally of plagioclase (labradorite to andesine), augite, and ilmenite and (or) magnetite. Locally occurring pyrite blebs are ubiquitous. Dikes range from a few cm to 20 m (an in.–65 ft) wide and as much as 5 km (3 mi) long. Occur throughout the Highlands, but intrude only Middle Proterozoic rocks

Zch **Chestnut Hill Formation (Late Proterozoic) (Drake, 1984)**—Interbedded arkose, ferruginous quartzite, quartzite conglomerate, metarhyolite, and metasaprolite. Confined to a few small areas north and northeast of Phillipsburg, on the western side of Bowling Green Mountain, northwest of High Bridge, and a few areas too small to show at this map scale

Ygm **Mount Eve Granite (Middle Proterozoic) (Drake and others, 1991a)**—Light-pinkish-gray- or grayish-tan-weathering, light-gray to pinkish-gray, medium- to coarse-grained granite containing microcline microperthite, quartz, oligoclase, and biotite. Accessory minerals include hornblende, biotite, magnetite, and allanite. Most of the rock is a syenogranite. Upper intercept U-Pb age 1,020±4 Ma (Drake and others, 1991a). Occurs in Pochuck Mountain area along New York boundary

Byram Intrusive Suite (Middle Proterozoic) (Drake, 1984)

Ybh **Hornblende granite**—Pinkish-gray- to medium-buff-weathering, pinkish-white or light-pinkish-gray, medium- to coarse-grained, gneissoid to indistinctly foliated granite and sparse granite gneiss composed principally of microcline microperthite, quartz, oligoclase, and hornblende. Some phases are quartz syenite or quartz monzonite. Includes small bodies of pegmatite and amphibolite not shown on map. U–Pb age approximately 1,090 Ma (Drake and others, 1991b)

Ybs **Hornblende syenite**—Tan- to buff-weathering, pinkish-gray or greenish-gray, medium- to coarse-grained, gneissoid syenite and lesser amounts of quartz syenite containing microcline microperthite, oligoclase, quartz, and hornblende. Some phases are monzonite or monzodiorite

Ybb **Biotite granite**—Pink- to buff-weathering, light-pinkish-gray, medium-grained, massive, moderately foliated granite composed of microcline microperthite, quartz, oligoclase, and biotite

Yba **Microperthite alaskite**—Pink- to buff-weathering, light-pinkish-gray or pinkish-white, medium- to coarse-grained, gneissoid to indistinctly foliated granite composed principally of microcline microperthite, quartz, and oligoclase. Includes small bodies of amphibolite not shown on map

Lake Hopatcong Intrusive Suite (Middle Proterozoic) (Drake and Volkert, 1991)

Ypg **Pyroxene granite**—Gray- to buff- or white-weathering, greenish-gray, medium- to coarse-grained, massive, gneissoid to indistinctly foliated granite containing mesoperthite to microantiperthite, quartz, oligoclase, and clinopyroxene. Common accessory minerals include titanite, magnetite, apatite, and trace amounts of pyrite. Some phases are monzonite, quartz monzodiorite, or granodiorite. Locally includes small bodies of amphibolite not shown on map

Yps **Pyroxene syenite**—Gray- to buff- or tan-weathering, greenish-gray, medium- to coarse-grained, massive, indistinctly foliated syenite composed of mesoperthite to microantiperthite, oligoclase, and clinopyroxene. Contains sparse amounts of quartz, titanite, magnetite, and trace amounts of pyrite

Ypa **Pyroxene alaskite**—Light-gray- or tan-weathering, greenish-buff to light-pinkish-gray, medium- to coarse-grained, massive, moderately foliated granite composed of mesoperthite to microantiperthite, oligoclase, and quartz. Common accessory minerals are clinopyroxene, titanite, and magnetite. Locally includes small bodies of amphibolite not shown on map

Ys **Syenite gneiss**—Light-pinkish-white- to buff-white-weathering, greenish-gray, medium-grained, moderately foliated rock consisting of two distinct phases: hornblende syenite gneiss containing microcline microperthite, oligoclase, hornblende, and opaque minerals; and pyroxene syenite gneiss containing microcline microperthite, oligoclase, clinopyroxene, and accessory amounts of titanite and opaque minerals. Despite the co-mingling of these two phases, they appear to belong respectively to the Byram and Lake Hopatcong Intrusive Suites. In Hamburg Mountain area

Metasedimentary Rocks (Middle Proterozoic)

Yk **Potassium-feldspar gneiss**—Light-gray- to pinkish-buff-weathering, pinkish-white to light-pinkish-gray, fine- to medium-grained, moderately foliated gneiss and lesser amounts of granofels composed of quartz, microcline, microcline microperthite, and local accessory amounts of biotite, garnet, sillimanite, and opaque minerals

Ym **Microcline gneiss**—Light-gray- to pinkish-white-weathering, tan to pinkish-white, fine- to medium-grained, well-layered gneiss composed principally of quartz, microcline, and lesser amounts of oligoclase. Common accessory minerals include biotite, garnet, magnetite, and, locally, sillimanite

Yb **Biotite-quartz-feldspar gneiss**—Gray-weathering, locally rusty, gray to tan or greenish-gray, fine- to medium-coarse-grained, moderately layered and foliated gneiss that is variable in texture and composition. Composed of oligoclase, microcline microperthite, quartz, and biotite. Locally contains garnet, graphite, sillimanite, and opaque minerals

Ymh **Hornblende-quartz-feldspar gneiss**—Pinkish-gray- to buff-weathering, light-pinkish-white to pinkish-gray, fine- to medium-grained, massive to moderately well layered gneiss containing microcline, quartz, oligoclase, hornblende, and magnetite. Locally contains garnet and biotite

Ymp **Clinopyroxene-quartz-feldspar gneiss**—Pinkish-gray- or pinkish-buff-weathering, white to pale-pinkish-white or light-gray, fine- to medium-grained, massive to moderately well layered gneiss composed of microcline, quartz, oligoclase, clinopyroxene, and trace amounts of epidote, biotite, titanite, and opaque minerals. Commonly interlayered with amphibolite or pyroxene amphibolite

Yp **Pyroxene gneiss**—White- to tan-weathering, greenish-gray, fine- to medium-grained, well-layered gneiss containing oligoclase, clinopyroxene, variable amounts of quartz, and trace amounts of opaque minerals and titanite. Some phases contain scapolite and calcite. Commonly interlayered with pyroxene amphibolite or marble

Yf **Franklin Marble**—White- to light-gray-weathering, white, grayish-white, or, less commonly pinkish-orange, coarse- to locally fine-crystalline calcite marble with accessory amounts of graphite, phlogopite, chondrodite, clinopyroxene, and serpentine. Contains pods and layers of clinopyroxene-garnet skarn, hornblende skarn, and clinopyroxene-rich rock. Thin layers of metaquartzite occur locally. Intruded by Mount Eve Granite in the Pochuck Mountain area. Franklin Marble is host to the Franklin and Sterling Hill zinc ore bodies; exploited for talc and asbestiform minerals near Easton, Pennsylvania. Subdivided into an upper marble, "Wildcat marble," and a lower marble, "Franklin marble," by New Jersey Zinc Co. geologists (Hague and others, 1956)

Yq **Quartzite**—Light-gray, medium-grained, massive- to well-layered, vitreous, partly feldspathic quartzite having sparse flakes of graphite. Associated with potassium-feldspar gneiss (Yk), biotite-quartz-feldspar gneiss (Yb), pyroxene gneiss (Yp), Franklin Marble (Yf), and pyroxene-epidote gneiss (Ype)

Ype **Pyroxene-epidote gneiss**—White- to light-gray-weathering, light-greenish-gray or greenish-buff, fine- to medium-grained, moderately layered and foliated gneiss composed principally of quartz, microcline, plagioclase, clinopyroxene, epidote, and sparse amounts of titanite. Some phases of this unit are quartz rich. May be interlayered with and probably related to pyroxene gneiss (Yp)

Ye **Epidote gneiss**—Light-gray- to pinkish-white-weathering, light-grayish-pink to pinkish-white, medium-grained, moderately layered and foliated gneiss containing quartz, microcline, and epidote. Some phases contain scapolite. May be interlayered with and related to potassium-feldspar gneiss (Yk), and (or) clinopyroxene-quartz-feldspar gneiss (Ymp). Two elongate bodies mapped east of Franklin

Losee Metamorphic Suite (Middle Proterozoic) (Drake, 1984)

Ylo **Quartz-oligoclase gneiss**—White-weathering, light-greenish-gray, medium- to coarse-grained, moderately layered to indistinctly foliated gneiss and lesser amounts of granofels composed of quartz, oligoclase or andesine, and, locally, biotite, hornblende, and (or) clinopyroxene. Contains thin amphibolite layers

Yla **Albite-oligoclase granite**—White-weathering, light-greenish-gray, medium- to coarse-grained granite composed of albite or oligoclase, quartz, and sparse amounts of hornblende or clinopyroxene. Petrogenetically related to quartz-oligoclase gneiss (Ylo), but Yla has a more granulitic texture. Includes small bodies of pegmatite not shown on map

Ylb **Biotite-quartz-oligoclase gneiss**—White- to light-gray-weathering, light- to medium-gray or greenish-gray, fine- to coarse-grained, massive to moderately well layered, foliated gneiss composed of oligoclase or andesine, quartz, biotite, and, locally, garnet. Commonly interlayered with amphibolite

Rocks of Uncertain Origin (Middle Proterozoic)

Yh **Hypersthene - quartz - plagioclase gneiss** — Gray- to tan-weathering, greenish-gray to greenish-brown, medium-grained, moderately well layered and foliated, greasy-lustered gneiss of charnockitic affinity composed of andesine or oligoclase, quartz, clinopyroxene, hornblende, hypersthene, and sparse amounts of biotite. Commonly interlayered with amphibolite and mafic-rich quartz-plagioclase gneiss

Yd **Diorite**—Gray- to tan-weathering, greenish-gray to brownish-gray, medium- to coarse-grained, greasy-lustered, massive diorite containing andesine or oligoclase, clinopyroxene, hornblende, hypersthene, and sparse amounts of biotite and magnetite. Amphibolite layers common

Ya **Amphibolite**—Gray- to grayish-black, medium-grained amphibolite composed of hornblende and andesine. Some phases contain biotite and (or) clinopyroxene. Ubiquitous and associated with almost all other Middle Proterozoic units. Some amphibolite is clearly metavolcanic in origin, some is metasedimentary, and some appears to be metagabbro

Yam **Migmatite**—Mixed rock consisting of amphibolite containing veins, lenses, layers, and irregular clots of albite-oligoclase granite or microperthite alaskite

Ymg **Monazite gneiss**—Buff-weathering, light-greenish-gray to greenish-buff, fine- to medium-grained, moderately well foliated, well-lineated gneiss composed of microcline microperthite, quartz, oligoclase, biotite, and monazite. Accessory minerals include hornblende, zircon, and opaque minerals. Mapped in Fox Hill Range area

Yhp **Hornblende-plagioclase gneiss**—White- to gray-weathering, greenish-gray, medium-grained, moderately well foliated gneiss containing hornblende, clinopyroxene, plagioclase, and trace amounts of apatite, titanite, and opaque minerals

Ybp **Biotite-plagioclase gneiss**—White- to light-gray weathering, greenish-gray, medium-grained, moderately well layered gneiss composed of biotite, plagioclase, and accessory amounts of hornblende, clinopyroxene, and, locally, garnet. Forms a long, thin layer on Mase Mountain

Yma **Microantiperthite alaskite**—White-weathering, locally rusty, light-greenish-gray, medium- to coarse-grained, gneissic granite and alaskite containing microantiperthite, quartz, oligoclase, and sparse amounts of hornblende, clinopyroxene, biotite, and magnetite

Yu **Middle Proterozoic rocks, undifferentiated**—Shown in cross sections *A–A′* through *D–D′* only

fnd **Formation and age not determined**—Shown in cross sections *A–A′* through *D–D′* only

BEDROCK GEOLOGIC MAP OF NORTHERN NEW JERSEY

By

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