Bedrock Geologic Map Unit Properties Table: Delaware Water Gap National Recreation Area

Gray-shaded units are not mapped within Delaware Water Gap National Recreation Area.

Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
DEVONIAN	Catskill Formation	Long Run Member (Dclr)	**Dclr** is 914 m (3,000 ft) of alternating beds of gray sandstone, and red siltstone and shale. Grain size becomes finer toward the tops of some beds, also known as a fining-upward sequence or Bouma cycle. Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Surface water and groundwater quality and quantity**—as an aquifer, **Dclr** can yield 150 L/min (40 gal/min); emerging groundwater is low in solutes, soft, and potentially corrosive.	**Paleontological resources**—**Dclr** contains rare spiriferid brachiopods, roots, and burrows. **Sedimentary features**—**Dclr** contains possible turbidites (submarine landslides). Planar bedding, crossbeds, red beds, mudcracks, channels, and load casts are also present. **Dclr** contains dark, yellowish-orange, ferroan (iron-rich) dolomite nodules.	**Appalachian mountain building and the assembly of Pangaea**—Catskill Formation rocks were deposited in a delta that migrated as the Acadian highlands rose to the southeast. The Catskill Formation is the youngest Paleozoic unit on the bedrock map. Younger Paleozoic rocks were eroded away from the Middle Delaware River valley region and adjacent Pocono Plateau. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Beaverdam Run Member (Dcbr)	**Dcbr** contains 91 m (300 ft) of greenish-gray sandstone with lesser amounts of siltstone and shale. Unit weathers to dark yellowish orange to brown. Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Surface water and groundwater quality and quantity**—as an aquifer, **Dcbr** can yield 170 L/min (45 gal/min).	**Paleontological resources**—**Dcbr** contains burrows, *Tentaculites*, crinoids, brachiopods, and plant fragments. **Sedimentary features**—planar bedding, crossbeds, channels, and load casts.	
		Walcksville Member (Dcw)	**Dcw** is 488 m (1,600 ft) of alternating greenish-gray sandstones and red shales. A notable, 1.2-m- (4-ft-) thick, grayish-reddish-purple shale chip conglomerate occurs in this unit. Fining-upward sequences occur in most beds. Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Surface water and groundwater quality and quantity**—as an aquifer, **Dcw** can yield 132 L/min (35 gal/min).	**Paleontological resources**—**Dcw** contains bioturbated beds. **Sedimentary features**—planar bedding, crossbeds, ripple laminations, and mudcracks.	
		Shohola Member (Dcs)	**Dcs** consists of interbedded 2- to 8-m- (5- to 25-ft-) thick greenish-gray and grayish red very fine to medium-grained sandstone and sandy shale with lesser amounts of gray sandstone and shale. Bedding in **Dcs** is thin to very thick. Unit is more than 610 m (2,000 ft) thick. Moderately high erosion resistance. Lower erosion resistance for shale layers.	None documented.	**Sedimentary features**—**Dcs** contains conglomerates and load casts near the bases of the sandstone beds. **Connections to park stories and resources**—greenish-gray and gray sandstone beds have been quarried for flagstone.	
		Analomink Red Shale Member (Dca)	**Dca** is about 30 m (100 ft) of medium grayish-red, silty, finely laminated shale with thin beds of brownish-gray sandy siltstone and very fine-grained sandstone. Moderate erosion resistance.	**Slope movements**—Thick shale units may form zones of weakness in the rock column, making undercut exposures prone to movement	None documented.	
		Delaware River Flags Member (Dcd)	**Dcd** contains cyclic sequences of gray, planar-bedded and cross-bedded, fine- to medium-grained sandstone with some thin red siltstone and claystone, as well as thin coarse-grained conglomerate beds. Individual beds within **Dcd** range from a few centimeters to more than 1 m (4 ft) thick. Maximum thickness of **Dcd** is 853 m (2,800 ft). Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Surface water and groundwater quality and quantity**—as an aquifer, **Dcd** can yield 379 L/min (100 gal/min), which is adequate for domestic wells.	**Connections to park stories and resources**—**Dcd** sandstones can split evenly into smooth flagstones. Sandstones are low-rank graywackes.	
		Towamensing Member (Dct)	**Dct** includes medium-gray sandstone interlayered with greenish-gray siltstone and shale. Some coarser-grained conglomerate layers are present locally. Locally, the thickness of **Dct** can reach 495 m (1,625 ft). Dct weathers to light gray to olive gray and pale brown to grayish orange. Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Surface water and groundwater quality and quantity**—as an aquifer, **Dct** can yield 114 L/min (30 gal/min). Emerging groundwater is soft.	**Sedimentary features**—crossbeds. **Connections to park stories and resources**—sandstones are "flaggy."	

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Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
DEVONIAN	Trimmers Rock Formation	Trimmers Rock Formation, undivided (Dtr)	**Dtr** consists of gray to olive-gray, thin- to medium-bedded sandstone, interlayered with siltstone and silty shale. Fining-upward cycles (Bouma cycles) are common in this unit. **Dtr** is about 323 m (1,060 ft) thick. Moderately high erosion resistance. Lower erosion resistance for shale layers.	**Slope movements**—**Dtr** tends to form a loose, colluvial shale-chip gravel. **Dtr** is more resistant and supports a steeper slope than does **Dmh** (below). **Surface water and groundwater quality and quantity**—as an aquifer, **Dtr** can yield 341 L/min (90 gal/min). Emerging groundwater is soft, low in solutes, and potentially corrosive. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—as an aquifer, **Dtm** and **Dtsb** can yield 227 L/min (60 gal/min). Emerging groundwater can contain excessive manganese locally.	**Paleontological resources**—**Dtr** fossil remains include diverse plants, corals, bryozoans, brachiopods, bivalves, gastropods, "worms," trilobites, arthropods, crinoids, and fish. **Sedimentary features**—planar laminations, crossbeds, load and groove casts. **Connections to park stories and resources**—some sandstones in the upper beds could be quarried for flagstones.	**Appalachian mountain building and the assembly of Pangaea**—mountains uplifted by the Acadian orogeny affected sedimentary system. Dtr, Dtm, and Dtsb record the transition between marine conditions and the advancing Catskill deltaic system. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Millrift Member (Dtm)	**Dtm** contains dark- to medium-gray siltstone, shale, and sandstone in thin- to medium-bedded exposures. Some sandstone beds are massive and thick bedded. The maximum thickness of this member is approximately 305 m (1,000 ft). Moderately high erosion resistance. Lower erosion resistance for shale layers.			
		Sloat Brook Member (Dtsb)	**Dtsb** contains more dark- to medium-gray siltstone and silt shale than does **Dtm**, which has more sandstone. The maximum thickness of this member is approximately 290 m (950 ft). Moderate erosion resistance.			
	Hamilton Group-Mahantango Formation	Mahantango Formation, undivided (Dmh)	**Dmh** is predominantly medium- to dark-gray, laminated to finely bedded siltstone, claystone, clay shale, and silty shale. Although regionally variable, **Dmh** is approximately 610 m (2,000 ft) thick. It weathers to grayish orange to dark yellowish orange and brown. Units have moderate erosion resistance; lower erosion resistance for claystone and shale-rich beds.	**Slope movements**—**Dmh** and **Dmhn** tend to weather into thick, shale-chip gravel that mantles slopes. **Dmh** cannot support steep slopes relative to other, sandstone-rich units (see **Dtr**). **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Seismic hazards**—slumps and slides within **Dmh** caused were triggered in part by a 2011 earthquake and the saturation of material in severe storm events. **Qoic** also flanks the road along this stretch. **Surface water and groundwater quality and quantity**—as an aquifer, **Dmh** can yield 265 L/min (70 gal/min). Emerging groundwater is soft to moderately hard, basic, low in solutes, and potentially corrosive.	**Paleontological resources**—**Dmh** contains bioturbated beds and biostromes. Fossils include brachiopods, crinoids, bryozoans, gastropods, pelecypods, trilobites, cephalopods, and solitary and colonial corals. Sea star *Hudsonaster wardi* was first described from Mahantango Formation rocks near Milford. **Dmhc** is a biostrome containing brachiopods, crinoids, bryozoans, gastropods, pelecypods, trilobites, cephalopods, and solitary (horn) and colonial (horn) corals. Unit is also known as the "Centerfield Reef" due to the abundance of fossils. Popular fossil collecting areas exist near Saylorsburg. **Sedimentary features**—the lower contact with **Dmb** (below) is gradational, with a marked difference in hardness. **Dml** is harder than **Dmb**.	**Appalachian mountain building and the assembly of Pangaea**—Hamilton Group rocks and fossils record shallower water conditions than those responsible for the Marcellus. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Upper Member (Dmu)	**Dmu** is medium-dark-gray, fairly coarse-grained, thin-bedded siltstone and silty shale. Unit is approximately 213 m (700 ft) thick.			
		Nis Hollow Member (Dmhn)	**Dmhn** contains medium-light- to medium-dark-gray, laminated to medium-bedded, blocky siliceous (contains abundant silica) siltstone and sandstone. In weathered outcrop exposures, **Dmhn** appears brown to dark yellowish brown and is about 5 m (15 ft) thick.			
		Centerfield Member (Dmhc)	**Dmhc**, a conspicuous zone about 274 m (900 ft) above the base of **Dmh**, is a 5- to 8-m- (15- to 25-ft-) thick biostrome (layered accumulation of fossils) consisting of medium-dark- to dark-gray calcareous siltstone and laminated to poorly bedded silty shale. Unit weathers to olive gray, grayish orange, and dark yellowish brown.			
		Lower Member (Dml)	**Dml** is medium-dark-gray, fairly coarse-grained, thin-bedded siltstone and silty shale. Unit is approximately 335 m (1,100 ft) thick.			
		Biostrome (Dmhf)	**Dmhf** consists of medium-light-gray siltstone biostrome (layered accumulation of fossils) beds that occur at varying stratigraphic horizons within **Dmh**. Weathered exposures of **Dmhf** are grayish orange, dark yellowish orange, and brown.			
		Mahantango Formation and Marcellus Shale, undivided (Dh)	**Dh** consists of shale and siltstone. The Hamilton Group is 790 to 850 m (2,600 to 2,800 ft) thick. Locally, **Dh** may include sandstone and conglomerate.			

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DEVONIAN	Hamilton Group-Marcellus Shale	Marcellus Shale (Dm)	**Dm** is dark-gray to grayish-black clay shale and silty clay shale. Some minor argillaceous (considerable clay content) siltstone beds occur locally. Unit is carbonaceous (contains carbon). **Dm** is approximately 290 m (950 ft) thick. Weathered exposures of **Dm** appear light to medium gray, light brown to yellowish brown, and dark yellowish orange to grayish orange. Erosion resistance is moderate.	**Slope movements**—**Dm** commonly weathers to produce thick, unconsolidated deposits that are prone to movement. The basal shales are locally oversteepened (in areas such as along U.S. Hwy 209) due to glacial erosion during the last ice age and are constantly spalling off, forming shale-chip rubble (**Qsr**) at cliff bases. **Marcellus Shale gas extraction**—Marcellus Shale is a regionally significant target for natural gas extraction. Viable deposits do not occur within the park, but proximity to active exploration poses resource management concerns. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—as an aquifer, **Dm** can yield 416 L/min (110 gal/min). Emerging groundwater is soft to moderately hard, basic, low in solutes, and potentially corrosive. Drilling for Marcellus Shale gas creates a potential water quantity and/or quality threat	**Paleontological resources**—marine fossils are present in **Dm**. Marcellus Shale contains fossil remains of plant material, conulariids, bryozoans, brachiopods, bivalves, "worms," cephalopods, trilobites, and arthropods. **Sedimentary features**—quartz-chlorite (chert) nodules occur parallel to bedding.	**Appalachian mountain building and the assembly of Pangaea**—Black, pyritic shales of **Dh**, **Dm**, **Dmb**, and **Dmsu** accumulated in an anoxic basin, which facilitated the burial of organic-rich sediments. That organic material became the natural gas and petroleum products now extracted throughout the northeast. Volcanic ash layers signal a return of tectonic activity and the beginning of the Acadian orogeny. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Brodhead Creek Member (Dmb)	**Dmb** is dark-gray, laminated to poorly bedded silty shale. Unit is approximately 244 to 274 m (800 to 900 ft) thick. The lower contact of **Dmb** is gradational with **Dmsu** (below). Erosion resistance is moderate.		**Paleontological resources**—**Dmb** is sparingly fossiliferous. **Type sections**—**Dmb** described from exposures near Stroudsburg. **Sedimentary features**—**Dmb** contains gray, shaly limestone concretions up to 0.3 m (1 ft) long.	
		Stony Hollow and Union Springs shale members, undivided (Dmsu)	**Dmsu** contains interlayered dark-gray, limy (limestone-rich) silty to sandy shale, silty shale, and limy shale. Unit is approximately 60 m (200 ft) thick. Continuous limestone beds pinch and swell within this unit. Erosion resistance is moderate.		**Paleontological resources**—**Dmsu** contains poorly preserved brachiopods and is considered sparingly fossiliferous.	
	Onondaga Limestone	Onondaga Limestone, undivided (Dou)	**Dou** members include shale and limestone of the Schoharie Formation (see **Dse**), Carlisle Center Siltstone, Buttermilk Falls Limestone (**Db**), and Espous Shale (see **Dse**). Moderate erosion resistance. **Db** is clayey to silty, thin- to medium-bedded limestone. Upper portions of the unit are medium- to dark-gray, fossiliferous, clayey limestone. Middle portions of the unit are medium-gray, fossiliferous, silty, limy claystone with some limestone lenses. The lower portions of the unit contain medium- to dark-gray, fossiliferous, very limy siltstone and claystone. **Db** is about 80 m (270 ft) thick. Moderate erosion resistance.	**Slope movements**—**Db** weathers to deep deposits of white, gray, orange, brown, and red clay. These clay deposits may be prone to movement. Pits and collapsed mine workings outline exposures of **Db**. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—carbonate rocks of **Db** buffer acidity in streams flowing over them.	**Paleontological resources**—lower portions of **Db** have large (up to 2.5 cm [1 in] in diameter) crinoid columns. **Db** contains ostracode and brachiopod debris. **Type sections**—**Db** described from exposures near Stroudsburg. **Sedimentary features**—chert nodules exist within **Db**. **Cave and karst**—**Dou** and **Db** host a variety of karst features. **Connections to park stories and resources**—chert nodules may have provided tool material for American Indians. **Db** has been utilized for road material.	**Appalachian mountain building and the assembly of Pangaea**—Onondaga Limestone was deposited during a period of marine shallowing (regression). Volcanic ash layers signal a return of tectonic activity and the beginning of the Acadian orogeny. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Buttermilk Falls Limestone (Db)				
	Palmerton Sandstone (Dpt)		**Dpt** consists of medium-dark- to very-light-gray, medium- to very coarse-grained sandstone and conglomeratic (coarser) sandstone. A few beds of siltstone and finer-grained sandstone occur in the lower portions of the unit. Weathered outcrops of **Dpt** appear pale yellowish orange to dark yellowish orange and grayish orange. Unit is locally 20 m (66 ft) thick. Sandstone and conglomerate have moderately high erosion resistance.	**Slope movements**—**Dpt** may be vulnerable to rockfall if undercut and exposed on slopes.	**Paleontological resources**—**Dpt** contains favositid corals, crinoid columnals, and brachiopod molds. **Sedimentary features**—**Dpt** may contain brown ironstone concretions. Rounded quartz pebbles in **Dpt** may be up to 2 cm (0.75 in) long.	**Appalachian mountain building and the assembly of Pangaea**—massive sandstones and conglomerates of this unit reflect a shift toward nearshore, higher-energy depositional environments during this period of the Devonian. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
	Schoharie Formation and Esopus Formation, undivided (Dse)		Mapped where **Ds** and **De** cannot be distinguished, **Dse** is poorly exposed and locally deeply weathered. In the upper portions, it contains evenly bedded, fossiliferous, cherty siltstone to fine-grained sandstone that appears gray in fresh exposures. Weathered exposures are gray, orange, and brown. Lower portions o.f **Dse** are dark-gray, laminated to fine-bedded silty shale and shaley siltstone. Generally weathers to darker tones than the upper portion. Total thickness of this unit is approximately 46 m (150 ft). **Dse** is exposed along Pennsylvania State Route 33.	**Slope movements**—**Dse** is deeply weathered in this area and may be prone to slumping and slope movements in areas exposed on slopes.	**Paleontological resources**—**Dse** is fossiliferous and contains abundant *Taonurus* and burrows. **Connections to park stories and resources**—occasional chert may have provided tool and trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—**Dse**, **Ds**, and **De** record a return to deeper water depositional environments following a period of sea level drop and subsequent erosion. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.

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DEVONIAN	Schoharie Formation (Ds)		**Ds** consists of medium-gray to grayish-black, medium- to thick-bedded calcareous (contains some limestone) siltstone and silty limestone. Beds range from a few centimeters to 2 m (6 ft) thick. **Ds** is approximately 30 m (100 ft) thick and weathers to light gray. It has less-developed cleavage (propensity to break apart on planar partings) than **De** (below). **Ds** is exposed in the Eureka Stone Co. quarry at the southwest end of Godfrey Ridge. **Ds** is more resistant than **De** to erosion.	**Slope movements**—calcareous cements may dissolve, leaving portions of this unit friable and prone to movement. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park.	**Paleontological resources**—**Ds** has burrowed layers (*Taonurus*) and brachiopods are common. The Schoharie Formation contains fossil remains of corals, brachiopods, gastropods, cephalopods, and trilobites. **Connections to park stories and resources**—occasional dark-gray chert may have provided tool and trade material for American Indians. **Ds** could be used for crushed stone and has been used for road material.	**Appalachian mountain building and the assembly of Pangaea**—**Dse**, **Ds**, and **De** record a return to deeper water depositional environments following a period of sea level drop and subsequent erosion. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
	Esopus Formation (De)		**De** contains medium- to dark-gray, shaley, laminated siltstone and lesser silty shale and minor calcareous (contains limestone) siltstone. **De** weathers to a lighter shade of gray. **De** is approximately 55 m (180 ft) thick. **De** is less resistant than **Ds** to erosion. Outcrops of **De** exist 1 km (0.6 mi) north of Bossardsville.	**Slope movements**—calcareous cements may dissolve, leaving portions of this unit friable and prone to Slope movements. Clayey layers of this unit may be prone to slumping if exposed on slopes. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park.	**Paleontological resources**—Brachiopods are uncommon, but the unit is extensively burrowed (*Taonurus* and *Skolithos*).	
	Oriskany Group	Oriskany Group, undivided (Do)	**Do** contains approximately 34 m (110 ft) of interbedded light- to dark-gray, thin to thick layers of conglomeratic, limy, coarse-grained quartz sandstone and silty, quartzose limestone beds. The sandstone component decreases lower in the unit. **Do** weathers to brownish orange and orangish gray. sandstones within **Do** are moderately resistant to erosion and form ledges up to 5 to 6 m (15 to 20 ft) thick.	**Slope movements**—Ledges may be prone to rockfall. Calcareous cements may dissolve, leaving portions of this unit friable and prone to Slope movements. Erosion resistance is moderately high. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—carbonate rocks of **Do** buffer acidity in streams flowing over them.	**Paleontological resources**—**Do** contains abundant spiriferid brachiopods and partly silicified (cemented by silica-rich compound) coquina. **Sedimentary features**—quartz pebbles within **Do** may be up to 1 cm (0.5 in) long. **Caves and karst**—limestone and calcareous cements within these units are soluble and may host karst features such as pits, caves, and sinking streams. **Connections to park stories and resources**—sandstone ledges within **Do** may provide nesting habitat. As determined from archaeological sites within the park, occasional chert beds and lenses provided tool and trade material for American Indians. **Do** has been utilized for road material.	**Appalachian mountain building and the assembly of Pangaea**—Oriskany Group rocks were deposited near sea level in supratidal and intertidal flats, barrier bars, and subtidal zones. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
		Ridgely Sandstone (Dr)	**Dr** contains medium- to coarse-grained, limonitic and hematitic (iron-rich), conglomeratic sandstone. Weathered outcrop exposures of **Dr** are gray to yellowish orange. Dr is less than 30 m (100 ft) thick.		**Paleontological resources**—**Dr** has spiriferid brachiopod molds. **Sedimentary features**—**Dr** contains pebbles up to 2 cm (0.75 in) long.	
		Ridgely Sandstone and Shriver Chert, undivided (Drs)	**Drs** includes **Dr** (above) and underlying Shriver Chert, which consists of interbedded, dark-gray chert and limestone in roughly equal amounts with minor medium- to light-gray, calcareous, medium- to very coarse-grained sandstone and conglomerate beds. The chert unit is 16 to 25 m (54 to 82 ft) thick.		**Paleontological resources**—chert layers contain abundant spiriferid brachiopods. **Connections to park stories and resources**—dark-gray chert (present as nodules, lenses, and irregular beds) may have provided tool and trade material for American Indians. Beds of chert may be more than 3 m (10 ft) thick.	

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DEVONIAN	Helderberg Group	Helderburg Group, undivided (Dhg) Port Ewen Shale, Minisink Limestone, and New Scotland Formation, undivided (Dph) Port Ewen Shale (Dp) Minisink Limestone and New Scotland Formation, undivided (Dmn) Coeymans Formation, undivided (Dc)	**Dhg** includes Alsen, Becraft, New Scotland (**Dmn**), Kalkberg, Coeymans (**Dc**), and Manlius limestones; and Port Ewen Shale (**Dph**, **Dp**), and Rondout Dolostone (**DSohr**, below). **Dph** consists of **Dp**, which is 27 m (90 ft) of fossiliferous, medium- to dark gray, irregularly bedded, limy siltstone and shale overlying 18 m (60 ft) of gray irregularly laminated (finer bedding) limy shale and siltstone. The Minisink Limestone (**Dph** and **Dmn**) is 4 m (14 ft) thick and consists of dark-gray, fine-grained, clayey limestone. The New Scotland Formation (**Dph** and **Dmn**) contains 23 m (75 ft) of dark-gray, fossiliferous silty, limy shale with lenses of clayey, fine-grained limestone. **Dc** is approximately 34 m (110 ft) of medium- to dark-gray, fossiliferous limestone and light-gray, coarse-grained sandstone with very coarse-grained quartz pebble conglomerate. **Dp** is exposed at the east end of Godfrey Ridge. Erosion resistance is moderate; it is higher for sandstone and conglomerate.	**Slope movements**—calcareous cements may dissolve, leaving portions of this unit friable and prone to movement. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—carbonate rocks of **Dmn** buffer acidity in streams flowing over them.	**Paleontological resources**—**Dph** is fossiliferous. **Dp** is burrowed and contains brachiopods, corals, ostracodes, trilobites, and crinoids. In an area north of Tocks Island, **Dc** includes a reef facies unit of light- to pinkish-gray, bioclastic (composed of fragments made by organisms) limestone. **Dc** also contains trace fossils. Rounded outcrop of Coeymans reef with stromatoperoids and other fossils along River Road is suitable for interpretation **Type sections**—Minisink Limestone (Dph or Dmn) described from exposures near Minisink Hills. Flatbrookville and Maskenozha members of New Scotland Formation (not mapped separately) described from exposures along "Fllatbrookville—Wallpack Center Road." Depue Limestone and Shawnee Island members of Coeymans Formation (not mapped separately) described from exposures near Shawnee on Delaware. Peters Valley Member of Coeymans Formation (not mapped separately) described from southwest side of Wallpack Ridge. Stormville Member of Coeymans Formation (not mapped separately) described from exposures on Godfrey Ridge. **Cave and karst**—limestone and calcareous cements within these units are soluble and may host karst features such as pits, caves, and sinking streams. **Connections to park stories and resources**—as determined from archaeological sites within the park, nodules and nodular dark-gray chert beds and lenses provided tool and trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—Trace fossils within **Dc** record alternating high-energy to moderately low-energy shallow marine environments during this period of the Devonian. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
DEVONIAN-SILURIAN	Lower part of the Helderburg Group and Rondout Formation, undivided (DShr)		**DShr** is poorly exposed limestone; argillaceous (contains an appreciable amount of clay) limestone; calcareous sandstone, conglomerate, and shale; and dolomite. Unit is approximately 61 m (200 ft) thick. Erosion resistance is moderate; it is higher for sandstone and conglomerate.	**Slope movements**—calcareous cements may dissolve, leaving portions of this unit friable and prone to movements.	See corresponding descriptions (**DSrp**, **DSohr**, **DSrd**, **Dmn**, and **Dc**).	See corresponding descriptions.
DEVONIAN-SILURIAN	Shriver Chert of the Oriskany Group, Helderburg Group and Rondout Formation, undivided (DSohr)		Unit **DSohr** includes the Shriver Chert (**Drs**), Port Ewen Shale (**Dph** and **Dp**), Minisink Limestone (**Dph** and **Dmn**), New Scotland Formation (**Dph** and **Dmn**), Coeymans Formation (**Dc**), and dolomite, shale, and limestone of the Rondout Formation (**DShr**, **DSrp**, and **DSrd**).	See corresponding descriptions.	See corresponding descriptions.	See corresponding descriptions.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
DEVONIAN SILURIAN	Rondout Formation (DSrp)	**DSrp** consists of dolostone, limestone, Binnewater Sandstone, High Falls Shale, Warwarsing Limestone, Decker Limestone, Bossardville Limestone (**Sbv**), and shale and dolostone of the Poxono Island Formation (**Sp**). Part of **DSu**. Unit ranges from 0 to 120 m (0 to 400 ft) thick.		See corresponding descriptions (**Sbv**, **Sp**, **DSrd**, and **DSu**).	See corresponding descriptions.
	Rondout and Decker formations, undivided (DSrd)	**DSrd** contains 9 m (30 ft) of light to dark gray calcareous shale and argillaceous limestone (contains a considerable amount of clay) with dark- to medium-gray dolomite and biostromal limestone. These layers overlie 26 m (85 ft) of calcareous quartz-pebble conglomerate, sandstone, siltstone, and argillaceous limestone. Erosion resistance is moderate; it is higher for sandstone and conglomerate.	**Slope movements**—Calcareous cements may dissolve, leaving portions of this unit friable and prone to movements. In areas where sandstone is undercut, the units may be prone to rockfall (e.g., Hibachi Rock). **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—carbonate rocks of **DSrd** buffer acidity in streams flowing over them.	**Paleontological resources**—**DSrd** contains leperditiid ostracodes and biostromal limestone. **Type sections**—Duttonville and Mashipacong members of Rondout Formation described from exposures near Duttonville. Clove Brook and Wallpack Center members of Decker Formation described from exposures near Dutonville and Wallpack Center, respectively. **Sedimentary features**—mudcracks, crossbeds, and planar bedding. **Cave and karst**—limestone, calcareous cement, and, to a lesser extent, dolomite within these units are soluble and may host karst features such as pits, caves, and sinking streams. **Connections to park stories and resources**—limestone beds have been quarried and the limestone burned to produce agricultural lime.	**Appalachian mountain building and the assembly of Pangaea**—These units represent hundreds of millions of years of mixed marine, nearshore, deepwater, and terrestrial deposition on the eastern coast of ancient North America. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
	Undifferentiated Devonian and Silurian rocks (DSu)	**DSu** is a sequence of carbonates (limestone and dolomite), shales, and siltstones, with minor calcareous sandstone and conglomerate. All of these rock types exist in a structurally complex configuration. Erosion resistance is moderate; it is higher for sandstone and conglomerate.	**Slope movements**—Calcareous cements may dissolve, leaving portions of this unit friable and prone to Slope movements. In areas where sandstone is undercut, the units may be prone to rockfall. **Surface water and groundwater quality and quantity**—as an aquifer, **DSu** can yield 606 L/min (160 gal/min). Carbonate rocks can yield much more, possibly because of increased permeability due to dissolution conduits. Emerging groundwater from noncarbonates is moderately hard and low in solutes. Emerging groundwater from carbonate units is high in solutes and hard to very hard.	See corresponding descriptions of Devonian and Silurian units.	**Appalachian mountain building and the assembly of Pangaea**—**DSu** represents hundreds of millions of years of mixed marine, nearshore, deepwater, and terrestrial deposition on the eastern coast of ancient North America. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
SILURIAN	Decker Formation (Sd)	**Sd** consists of fine- to medium-bedded, arenaceous, argillaceous (contains considerable clay), pyritic, partly dolomitic limestone interlayered with minor amounts of conglomerate, shale, siltstone, and dolomite. Limestone is very fine to medium grained, with shades of gray, green, and purple in fresh exposures. Weathered exposures are gray, yellow, and orange. The sandstones are mostly gray and weather to gray, yellow, and orange. The shale and siltstone have green and gray shades that weather to yellowish gray and orange. Dolomite is gray and green and weathers to pale yellowish orange. **Sd** is approximately 21 to 30 m (70 to 100 ft) thick. Erosion resistance is moderate; it is higher for sandstone and conglomerate.	**Slope movements**—Calcareous cements and limestones may dissolve, leaving portions of this unit friable and prone to Slope movements. In areas where sandstone is undercut, the unit may be prone to rockfall.	**Paleontological resources**—**Sd** contains brachiopods, corals, and ostracodes, as well as trace fossils and trails. **Type sections**—Clove Brook and Wallpack Center members of Decker Formation described from exposures near Dutonville and Wallpack Center, respectively. **Sedimentary features**—mudcracks. Conglomeratic layers contain quartz pebbles up to 1.3 cm (0.5 in) long.	**Appalachian mountain building and the assembly of Pangaea**—Units record the continued marine depositional setting during the Silurian and into the Devonian. Deformed during the Alleghany Orogeny, during which Pangaea was assembled. The paleontological record of the Decker Formation records a shallow marine, moderate- to low-energy environment punctuated by higher-energy storm-like conditions.

Gray-shaded units are not mapped within Delaware Water Gap National Recreation Area.

Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
SILURIAN	Bossardville Limestone (Sbv)		**Sbv** is predominantly fine-grained limestone, and argillaceous (contains considerable clay) and pyritic limestone. Locally, thin layers of light-olive-gray shale exist. Fresh exposures of **Sbv** are gray and weather to grayish orange. Unit is approximately 30 m (100 ft) thick. Erosion resistance is moderately high.	**Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—carbonate rocks of **Sbv** buffer acidity in streams flowing over them.	**Paleontological resources**—**Sbv** contains possible algal laminations and leoerditiid ostracode fossil-rich layers. Other fossils in this unit include crinoids, brachiopods, and rugose corals. **Sedimentary features**—laminations, ripples, and mudcracks. **Cave and karst**—limestone within this unit is soluble and may host karst features such as pits, caves, and sinking streams. **Connections to park stories and resources**—**Sbv** has been quarried for concrete aggregate, road material, and cement limestone. Limestone from this unit was burnt to produce agricultural lime. Quarries of **Sbv** exist in Bossardsville.	**Appalachian mountain building and the assembly of Pangaea**—Units record the continued marine depositional setting during the Silurian and into the Devonian. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
SILURIAN	Poxono Island Formation (Sp)		**Sp** consists of green, gray, and pink, laminated to medium-bedded, very fine-grained dolomite interbedded with argillaceous (contains considerable clay) limestone with similar characteristics. Unit weathers to yellowish orange. Some reddish, sandy shale is present in lower portions of the unit. Thickness of **Sp** is approximately 213 m (700 ft). Erosion resistance is moderately high.	**Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park.	**Paleontological resources**—**Sp** contains ostracodes. **Type sections**—**Sp** described from exposures along Delaware River opposite Poxono Island. **Sedimentary features**—mudcracks and 15 cm (0.5 ft) of dessication breccia (forms when mudcracks are disturbed by sudden flow and piled up, then buried). **Cave and karst**—carbonate rocks within this unit are soluble and may host karst features such as pits, caves, and sinking streams.	**Appalachian mountain building and the assembly of Pangaea**—Unit represents a return to predominantly marine conditions following the terrestrial setting of the Bloomsburg Red Beds. Deformed during the Alleghany Orogeny, during which Pangaea was assembled.
SILURIAN	Bloomsburg Red Beds	Bloomsburg Red Beds, disseminated chalcocite (Sbcu)	**Sbcu** contains disseminated chalcocite as an isolated portion of **Sb**.	**Slope movements**—blocks of sandstone and conglomerate susceptible to rockfall where thick, erosion resistant beds are undercut on steep slopes. In some areas, such as Sambo Island, units act as "polished" slip surfaces for soil slumps (may contain unconsolidated glacial till **Qit**, **Qot**, **Qtk**, or **Qtq**). Known soil slips, rockfalls, and debris flows in the Bloomsburg Red Beds exist within the park. Faults along bedding planes within the formation increase the potential for slope movements of overlying rock formations where excavation (e.g., for roads) exposes these zones of weakness. **Sb** and **Sbcu** identified as particularly susceptible to slope movement. Fractures and joints created rockfall hazards. **Abandoned mineral lands**—gates have been installed to prevent human access, but allow bat access to the Pahaquarry copper mine. **Surface water and groundwater quality and quantity**—faults along bedding within the Bloomsburg Red Beds are commonly zones of weathering and groundwater flow.	**Delaware Water Gap**—Prominent unit within the Gap. **Paleontological resources**—contains the first occurrence in New Jersey of an ancestral horseshoe crab and *Skolithos* burrows (indicating intermittent brackish-water setting). **Sb** contains fish scales in several places. **Folds and Faults**—**Sb** is exposed within the Dunnfield Creek syncline, visible within the Gap. **Sedimentary features**—"red beds" formed when sediments or rocks containing iron were exposed to oxygen, indicating terrestrial deposition. **Sb** also contains scattered ferroan (iron-rich) dolomite concretions. Additional sedimentary features include crossbeds, planar bedding, mudcracks, cut-and-fill structures, and channels. Mudcracks and angular fragments similarly suggest a continental or terrestrial depositional setting during this period of the Silurian. **Connections to park stories and resources**—**Sb** has been quarried for road material and fill. Pahaquarry Copper Mine targeted **Sbcu**. Conglomeratic layers contain clasts of angular quartz and red jasper up to 1 cm (0.5 in) long. Bedding plane faults and fractures in Bloomsburg Red Beds rendered the proposed location of the Tocks Island Dam unsuitable.	**Appalachian mountain building and the assembly of Pangaea**—meandering streams deposited **Sb** in lower energy settings than those of **Ss**. Mudcracks reveal periods of dessication where water flow ceased completely. Folds formed during the Alleghany Orogeny, during which Pangaea was assembled.
SILURIAN	Bloomsburg Red Beds	Bloomsburg Red Beds (Sb)	**Sb** is dominated by red, green, and gray sandstone, siltstone, and shale, with minor amounts of conglomeratic sandstone. Overall thickness of the unit is about 457 m (1,500 ft). Massive beds within the unit may be more than 3 m (10 ft) thick. Fining-upward sequences are common. The lower contact of **Sb**, at the base of the first red bed encountered moving from the base upsection, is remarkably sharp and irregular. It cuts across bedding to rise more than 152 m (700 ft) within a horizontal distance of less than 2 km (1 mi) in the Delaware Water Gap.			

Gray-shaded units are not mapped within Delaware Water Gap National Recreation Area.

Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
SILURIAN	Shawangunk Formation	Shawangunk Formation, undivided (Ss)	**Ss** contains gray to olive-gray, unevenly to moderately well bedded quartzite and conglomeratic quartzite, with minor amounts of siltstone and shale. Unit is 335 to 387 m (1,100 to 1,270 ft) thick. **Ss** has high erosion resistance.	**Slope movements**—Slope failures include documented rockfalls within the park. **Ss, Ssl, Ssm** identified as particularly susceptible to slope movement. Fractures and joints create rockfall potential. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park. **Surface water and groundwater quality and quantity**—as an aquifer, **Ss** has low yields (up to 19 L/min [5 gal/min]). Emerging groundwater is low in solutes, soft, and potentially corrosive.	**Delaware Water Gap**—Prominent units within the Gap. **Sst** is the resistant unit exposed atop Kittatinny Mountain and within the Gap. **Ssl** and **Ssm** visible in the Gap. **Paleontological resources**—three species of the enigmatic jellyfish-like genus *Rutgersella* were originally described from discoveries near the Gap. **Ssl** is burrowed with trails, and contains rare ball-and-pillow structures. **Ssl** contains rare fossils of eurypterids, *Dipleurozoa*, and *Lingula*. These resources may be prone to theft where exposed near visitor use areas. **Ssm** contains trace fossils including *Skolithos verticalis* and *Arthrophycus*. **Type sections**—**Sst** and **Ssm** described from exposures along I-80 within the Gap. **Ssl** described from exposures near Lehigh Gap. **Folds and faults**—in some places, a detachment or decollement occurs along the lower contact of **Ss**. This type of surface represents movement during mountain building. **Sst** forms the ridge of the Cherry Creek anticline. Tilted layers of **Ssl** and **Ssm** are visible in the Gap. **Sedimentary features**—**Ss** contains shale pebbles up to 5 cm (2 in) long. Quartzite in **Ss** is limonitic (iron rich), pyritic (iron sulfide), and feldspathic (contains feldspar). **Sst** contains some ferroan dolomite and calcite concretions. Quartz and argillite pebbles up to 5 cm (2 in) long occur in **Sst**. Features also include planar bedding, channels, mudcracks, flaser bedding, and crossbeds. **Ssl** contains rare collophane (carbonate fluorapatite) nodules and quartz pebbles. **Ssl** is limonitic, pyritic, and graphitic (see **Ss**). **Taconic Unconformity**—Silurian Shawangunk Formation sediments were deposited atop an erosional surface on the Ordovician Martinsburg Formation. **Cave and karst**—Cold Air Cave formed by an assemblage of boulders from the Shawangunk Formation. **Connections to park stories and resources**—ridges and cliffs of the Shawangunk Formation are part of the Kittatinny-Shawangunk National Raptor Migration Corridor, which also provides breeding and nesting habitat for many bird species. **Sst** and **Ssm** may be used as building stone.	**Appalachian mountain building and the assembly of Pangaea**—Lower contacts of **Ss** and **Ssl** are unconformable, indicating a period of erosion or nondeposition termed the Taconic Unconformity. Shawangunk Formation rocks were deposited as coarse-grained terrestrial, high-energy fluvial sediments, marking erosion of the Taconic highlands. Folds formed during the Alleghany Orogeny, during which Pangaea was assembled.
		Tammany Member (Sst)	**Sst** contains 168 to 457 m (550 to 1,500 ft) of gray, fine- to coarse-grained, thin- to thick-bedded conglomeratic quartzite and scant, interlayered, dark-gray argillite (a compact claystone that has been partially changed by heat and/or pressure, but not enough to become slate).			
		Lizard Creek Member (Ssl)	**Ssl** consists of gray to olive, fine- to coarse-grained, thin- to thick-bedded argillite (a compact claystone that has been partially changed by heat and/or pressure, but not enough to become slate) and quartzite. Some siltstone and shale beds occur locally. Weathered exposures of this unit appear grayish to dark yellowish orange. Unit is 83 to 183 m (273 to 600 ft) thick.			
		Minsi Member (Ssm)	**Ssm** is gray to olive, fine- to coarse-grained, thin- to thick-bedded quartzite interbedded with dark-gray argillite (a compact claystone that has been partially changed by heat and/or pressure, but not enough to become slate). Weathered exposures of **Ssm** appear light brown to dark yellowish orange and gray. Unit is 76 m to 92 m (250 to 303 ft) thick.			

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Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
SILURIAN-ORDOVICIAN	Beemerville Intrusive Suite	Undifferentiated dikes (SObl)	**SObl** includes discrete, crosscutting (cuts across fabrics of surrounding country rock) igneous intrusions of lamprophyre, tinguaite, phonolite, bostonite, and malignite. Moderately high erosion resistance.	**Slope movements**—Units may weather to produce slippery clay-rich material that is prone to slumping on slopes; however, these units are highly localized and probably do not occur in abundance in any single area. Where unweathered, units may pose rockfall hazards when more resistant than the surrounding country rock.	None documented.	**Appalachian mountain building and the assembly of Pangaea**—The Beemerville Intrusive Suite (or Complex) represents rocks emplaced in subsurface plutons following the Taconic Orogeny. They intruded rocks of the Martinsburg Formation. **Obs** of the Beemerville Intrusive Suite produced an age of 424 ± 20 million years ago by the Rb-Sr method and 437 ± 22 million years by the K-Ar method. **Obt** occurs as thin dikes (intrusions that cut the fabric of the surrounding rock) in **Obs** and in sills (intrusions that parallel the fabric of the surrounding rock) and dikes in the Martinsburg Formation **Obp** occurs as thin dikes in **Obt** and in sills and dikes within the Martinsburg Formation and Beekmantown Group. **Obb** occurs as dikes and sills within the Martinsburg Formation. **Obm** occurs as sills in the Martinsburg Formation. **Obla** occurs as dikes in the Martinsburg Formation, Beekmantown Group, and Allentown Dolomite. **Obo** (biotite grains from Rutan Hill) produced an age of 436 ± 41 million years by the Rb-Sr technique and 437 ± 22 million years by the K-Ar technique.
		Nepheline syenite (Obs)	**Obs** is medium- to dark-gray, medium- to coarse-grained syenite. In general, the unit is undeformed, but it exhibits flow foliation (banding created by parallel alignment of alternating dark and light minerals). **Obs** contains the following minerals: nepheline, orthoclase, socialite, aegirine, and biotite with minor amounts of magnetite, apatite, titanite, fluorite, zircon, and pyrite. Moderately high erosion resistance. **Obs** occurs in two stocks and a small plug (types of igneous intrusion) in the Rutan Hill area.			
		Tinguaite (Obt)	**Obt** consists of medium- to dark-gray and greenish-gray, fine-grained igneous rock. **Obt** contains the following minerals as phenocrysts (relatively large crystals): nepheline, orthoclase, aegirine, and biotite. These minerals also occur in the finer-grained surrounding groundmass, along with minor amounts of magnetite, apatite, titanite, and zircon. Moderately high erosion resistance.			
		Phonolite (Obp)	**Obp** consists of medium-dark-gray, very fine-grained rock. Much of **Obp** has been altered or weathered (sericitized [replacing original minerals with sercitic muscovite] and chloritized [replacing original minerals with chlorite] by hot, hydrothermal fluids), albitized (process by which calcium-rich plagioclase is replaced by sodium-rich albite) and/or carbonatized (replacement of original minerals by carbonate minerals). **Obp** contains nepheline and orthoclase.			
		Bostonite (Obb)	**Obb** medium- to dark-gray, very fine-grained rock with conspicuously large crystals of altered orthoclase. orthoclase phenocrysts occur in a finer-grained groundmass (matrix) of orthoclase, microperthite, and/or plagioclase, and minor amounts of aegirine, biotite, magnetite, apatite, and zircon.			
		Malignite (Obm)	**Obm** contains dark-gray, medium- to coarse-grained rock. Bluish-white orthoclase, white nepheline, and abundant biotite make up the larger crystals (phenocrysts) in a fine-grained matrix. the matrix of **Obm** contains orthoclase, nepheline, biotite, aegerine, melanite, magnetite, apatite, and titanite.			
		Lamprophyre (Obla)	**Obla** contains dark-gray to grayish-black, very fine-grained and altered mafic (low in silica content) rock. original mineralogy of **Obla** is difficult to discern given the high degree of alteration.			
		Ouachitite breccia (Obo)	**Obo** is dark-gray to black breccia (a chaotic mix of angular fragments in a finer-grained matrix). larger fragments in **Obo** include potassic (contains potassium) synite, lamprophyre, and carbonatite, as well as exotic (not part of local melts) pieces of Middle Proterozoic rocks, carbonate rocks of the Lehigh Valley sequence, and slaty Martinsburg Formation (see **Omp**, **Omhp**, **Omr**, **Omrg**, and **Omb**). The groundmass of **Obo** contains extremely fine-grained calcite, magnetite, biotite, chlorite, albite, and apatite and somewhat larger crystals of biotite, pyroxene, orthoclase, magnetite, apatite, and nepheline.			

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Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
ORDOVICIAN	Hornfels (Omh)		**Omh** is a dark-gray to black, extremely fine-grained rock. Very high erosion resistance.	None documented.	None documented.	**Appalachian mountain building and the assembly of Pangaea**—**Omh** is an example of contact metamorphism due to the intense heat associated with emplacement of **Obs** within the Martinsburg Formation. Other bodies of hornfels exist around the large intrusive sills of the Beemerville Intrusive Suite, but were not mapped due to lack of adequate exposure.
ORDOVICIAN	Martinsburg Formation	Pen Argyl Member (Omp)	**Omp** contains dark-gray to nearly black, thick- to thin-bedded claystone slate. Claystone is cyclically interlayered with quartzose slate and carbonaceous (contains carbon) slate. Fining-upward sequences are common. Unit is more than 1,524 m (5,000 ft) thick.	**Slope movements**—claystones and shales in these units may form zones of weakness prone to failure when the unit occurs on a slope. Weathered slates and shales are clay rich and may be prone to slumping. More-resistant greywackes pose a rockfall hazard when undercut on slopes. No significant landslide involves this unit within the park. **Omrg** identified as particularly susceptible to slope movement. **Paleontological resource management**—a park-specific paleontological resource survey could provide detailed site-specific recommendations for inventory, monitoring, interpretation, and protection of fossils within the park.	**Delaware Water Gap**—**Omr** is exposed at the base of the Gap. **Paleontological resources**—**Omr** contains scant graptolites. **Omhp** contains graptolites. assigned to the *Climacograptus spiniferus* zone; assigning an Edenian (Caradocian) age within the Ordovician (about 455 million years ago). In general, the Martinsburg Formation contains fossil remains of conulariids, bryozoans, brachiopods, bivalves, nautiloids, gastropods, trilobites, "worms," and crinoids. **Type sections**—**Omp** described from exposures near Pen Argyl. **Omhp** described from exposures in High Point State Park. **Omr** described from exposures near Ramseyburg. **Omb** described from exposures along Bushkill and Little Bushkill creeks. **Folds and faults**—tilted layers of **Omr** are visible at the eastern edge of the Gap. **Sedimentary features**—**Omp** contains sole marks and possible turbidites (submarine landslides). **Omhp** includes scoured shale remnants, rip-up clasts, graded bases, parallel laminated tops, and load casts. Greywacke is generally a dark-gray, compact, coarse-grained sandstone that consists of poorly sorted, angular to subangular grains of quartz and feldspar, with a variety of dark rock and mineral fragments embedded in a compact clay-rich matrix. **Omr** and **Omb** contains possible turbidites (submarine landslides). **Taconic Unconformity**—Silurian Shawangunk Formation sediments were deposited atop an erosional surface on the Ordovician Martinsburg Formation. **Connections to park stories and resources**—**Omp** and **Omb** were extensively quarried for slate and used as lightweight aggregate and fill. Active quarries still exist in these units (not inside the park). The Martinsburg Formation erodes into rolling hills. **Omr** and **Omrg** were targets in slate quarries.	**Appalachian mountain building and the assembly of Pangaea**—Martinsburg Formation sediments were deposited in a rapidly subsiding basin as the Iapetus Ocean closed. The source area for Martinsburg sediments was Appalachia to the southeast. As the basin deepened, deep-sea sediments and sediments from underwater mass-wasting events (turbidites) accumulated. The top of the Martinsburg Formation was exposed and heavily eroded during a period of nondeposition, prior to deposition of the Shawangunk Formation. That period corresponded to the close of the Taconic Orogeny.
ORDOVICIAN	Martinsburg Formation	High Point Member (Omhp)	**Omhp** is dark-gray greywacke with intervals or interbeds of dark shale. Unit weathers to light gray and pale yellowish brown. Silica cements dominate, but carbonate cements exist locally. Unit is approximately 114 m (375 ft) thick locally.			
ORDOVICIAN	Martinsburg Formation	Ramseyburg Member (Omr)	**Omr** consists of dark-gray slate with alternating beds of gray, thick- to thick-bedded greywacke and greywacke siltstone (20% to 30% of the unit). Unit is approximately 930 m (2,800 ft) thick. Fining-upward (Bouma) sequences are common, but are often truncated in this unit.			
ORDOVICIAN	Martinsburg Formation	Ramseyburg Member-graywacke beds (Omrg)	**Omrg** contains prominent greywacke-bearing layers with slate.			
ORDOVICIAN	Martinsburg Formation	Bushkill Member (Omb)^	**Omb** is dark- to medium-gray, thin-bedded to laminated claystone slate and occasional quartzose and greywacke siltstone and carbonaceous (contains carbon) slate. **Omb** also contains minor dolomite lenses. Fining-upward (Bouma) sequences are common. **Omb** grades downward into **Oj** by increasing carbonate content. Unit is up to 1,220 m (4,000 ft) thick locally. greywacke within **Omb** contains beds with muscovite, chlorite, albite, and quartz. See description of **Omhp**. Mapped areas of **Omb** are restricted to the extreme southeastern corner of the park.			
ORDOVICIAN	Austin Glen Formation (Oag)		**Oag** contains graywacke and shale. **Oag** is part of the Lorraine, Trenton, and Black River groups and is up to 490 m (1,600 ft) thick. Erosion resistance is moderate.	**Slope movements**—shale in this unit may form zones of weakness prone to failure when the unit occurs on a slope.	None documented.	**Appalachian mountain building and the assembly of Pangaea**—by the time Oag is deposited, clastic sedimentation is predominant. Deformed during the Taconic and Alleghany orogenies. **Oag** is the last unit deposited prior to deposition of the Martinsburg Formation.

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Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
ORDOVICIAN	Jacksonburg Limestone	Jacksonburg Limestone (Oj)	**Oj** consists of gray, medium- to coarse-grained, well-bedded limestone. At the base of **Oj** is a dolomite pebble to cobble conglomerate. Limestone becomes more shaly toward the top of the unit. **Oj** is approximately 38 to 61 m (125 to 200 ft) thick. erosion resistance is moderately high.	None documented.	**Paleontological resources**—**Oj** and **Ojl** contain conodonts of the North American Midcontinent Province Conodont Fauna 8–9; indicating Rocklandian and Kirkfieldian time (Llandeilian age) within the middle Ordovician (about 460 million years ago) **Cave and karst**—carbonate rocks within these units are soluble and may host karst features such as pits, caves, and sinking streams. Jacksonburg Limestone landscapes have lakes and sinkholes. **Connections to park stories and resources**—**Oj** may weather to produce calcium-rich soils.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. **Oja** and **Ojl** were among the last (youngest) units deposited as part of the massive carbonate bank of the Iapetus Ocean. Deformed during the Taconic and Alleghany orogenies. **Oj** occurs in tectonic units above the Sarepta thrust fault.
		Jacksonburg Limestone-cement limestone facies (Ojl)	**Ojl** is gray, medium- to coarse-grained, well-bedded calcarenite (arenite is a consolidated sedimentary rock composed of sand-sized fragments with a pure or nearly pure chemical cement) and fine to medium crystalline limestone. **Ojl** is approximately 20 to 30 m (66 to 98 ft) thick. erosion resistance is moderately high.			
	Sequence at Wantage (Ow)		**Ow** consists of interbedded gray to dark-gray limestone, dolomite, conglomerate, siltstone, and shale. All rock types are thin- to medium-bedded with limestone generally grading downsection into silty argillite (a compact claystone that has been partially changed by heat and/or pressure, but not enough to become slate). Weathered exposures are yellowish brown to olive gray. Unit ranges in thickness from 0 to 492 m (0 to 150 ft). Erosion resistance is moderately high; it is higher for conglomerates.	**Slope movements**—Calcareous cements may dissolve, leaving portions of this unit friable and prone to Slope movements. In areas where conglomerate is undercut, the units may be prone to rockfall.	**Sedimentary features**—crossbeds. **Cave and karst**—limestone, calcareous cement, and, to a lesser extent, dolomite within this unit are soluble and may host karst features such as pits, caves, and sinking streams. **Connections to park stories and resources**—chert in **Ow** may have provided tool and/or trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. Deformed during the Taconic and Alleghany orogenies.
	Beekmantown Group	Upper part (Obu)	**Obu** consists of dolomite and minor limestone. erosion resistance is moderately high.	**Slope movements**—In areas where quartzite is undercut, the units may be prone to rockfall.	**Paleontological resources**—**Oe** and **Or** contain conodonts of the *Rossodus manitouensis* zone of the North American Midcontinent Province Conodont Fauna; which date it to Ibexian (Tremadocian) age within the early Ordovician, or about 470 to 485 million years ago. **Cave and karst**—carbonate rocks (dolomite) within this unit are soluble and may host karst features such as pits, caves, and sinking streams. Solution collapse breccia may also be present; it forms when overlying material collapses into dissolved pits within limestone or evaporate deposits (salts) prior to the consolidation of sediments. **Connections to park stories and resources**—nodular and bedded chert in **Oe** may have provided tool and/or trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. Deformed during the Taconic and Alleghany orogenies.
		Lower part (Obl)	**Obl** contains dolomite and minor limestone. Erosion resistance is moderately high			
		Epler Formation (Oe)	**Oe** consists of interbedded, very fine-grained to nearly cryptocrystalline, gray limestone and darker dolomite. **Oe** ranges from 200 to 270 m (650 to 885 ft) thick. **Oe** also contains orthoquartzite. Erosion resistance is moderately high; it is very high for orthoquartzite. **Oe** is exposed in the Paulins Kill window.			
		Rickenbach Dolomite (Or)	**Or** includes gray, fine- to coarse-grained dololutite, dolarenite (arenite is a consolidated sedimentary rock composed of sand-sized fragments with a pure or nearly pure chemical cement), and dolorudite (rudite is a consolidated sedimentary rock composed of grains larger than sand with a pure or nearly pure chemical cement). Lower portions of the unit are thick bedded, with bedding becoming thinner and more laminated upsection. Unit ranges from 135 to 220 m (443 to 722 ft) thick. Erosion resistance is moderately high. **Or** grades downward into **Os**.			

Gray-shaded units are not mapped within Delaware Water Gap National Recreation Area.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
ORDOVICIAN	Stonehenge Formation (Os)	**Os** consists of gray, fine- to medium-grained limestone with moderate amounts of interbedded, laminated dolomite and dark-gray chert. Unit ranges from 84 to 198 m (275 to 650 ft) thick. In portions of **Os** that have undergone extensive deformation, boudins (sausage-shaped forms) of dolomite appear to "float" in the limestone. **Os** occurs only in tectonic units above the Sarepta thrust fault.Erosion resistance is moderately high.	None documented.	**Paleontological resources**—dolomite and limestone in **Os** are commonly mottled and burrowed. Fossils include conodont fauna of zone A to the *Rossodus manitouensis* zone of the North American Midcontinent Province Conodont Fauna; the fossil remains in this unit date it precisely to Ibexian (Tremadocian) age within the early Ordovician, or about 470 to 485 million years ago. **Cave and karst**—carbonate rocks and, to a lesser extent, dolomite within this unit are soluble and may host karst features such as pits, caves, and sinking streams. Solution collapse breccia may also be present; it forms when overlying material collapses into dissolved pits within limestone or evaporate deposits (salts) prior to the consolidation of sediments. **Connections to park stories and resources**—nodular chert in **Os** may have provided tool and/or trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. **Os** grades downward into the Allentown Dolomite (**OCa**), marking more or less continuous deposition at this time. Deformed during the Taconic and Alleghany orogenies.
ORDOVICIAN-CAMBRIAN	Allentown Dolomite (OCa)	**OCa** contains gray, very fine- to medium-grained dolomite. **OCa** weathers to an alternating light- and dark-gray banded appearance. Unit also contains scattered beds and lenses of quartzite. Unit is approximately 575 m (1,900 ft) thick in northern New Jersey. Thrust faulting truncates **OCa**, making the determination of its total thickness difficult. Erosion resistance is moderately high; it is very high for quartzite.	**Slope movements**—In areas where quartzite is undercut, the units may be prone to rockfall.	**Paleontological resources**—**OCa** contains oolite layers and algal stromatolites (fossil algae). Shelly fauna exist near the top and bottom of the unit elsewhere in New Jersey and place **OCa** in the Trempealeauan and Dresbachian ages of the Ordovician and Cambrian, respectively (about 490 to 500 million years ago). **Sedimentary features**—ripple marks and mudcracks. **Cave and karst**—dolomite within this unit is somewhat soluble and may host karst features such as pits. **Connections to park stories and resources**—nodular chert in **OCa** may have provided tool and/or trade material for American Indians.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. Deformed during the Taconic and Alleghany orogenies.
	Carbonate rocks (OCc)	Carbonate rocks can include limestones and dolomites. This unit occurs as bedrock on the surficial geologic map of the area. More specific descriptions occur throughout this table. Erosion resistance is moderately high.	None documented.	**Cave and karst**—carbonate rocks (dolomite) within this unit are soluble and may host karst features such as pits, caves, and sinking streams.	**Appalachian mountain building and the assembly of Pangaea**—carbonate deposition in the Iapetus Ocean continued from the Cambrian through much of the Ordovician. Deformed during the Taconic and Alleghany orogenies.
CAMBRIAN	Leithsville Formation (Cl)	**Cl** is thick-bedded, medium-gray, finely crystalline dolomite cyclically interlayered with platy and shaly dolomite. In some places, the unit contains light-gray to tan phyllite with beds and stringers (small, irregular bodies) of quartz and dolomite sandstone. Locally, unit is about 350 m (1,148 ft) thick. Erosion resistance is moderately high.	None documented.	**Paleontological resources**—**Cl** contains archaeocyathids. **Cave and karst**—carbonate rocks (dolomite) within this unit are soluble and may host karst features such as pits, caves, and sinking streams.	**Appalachian mountain building and the assembly of Pangaea**—originally deposited in the Iapetus Ocean. Deformed during the Taconic and Alleghany orogenies. **Cl** likely contains a major intraformational disconformity (period of nondeposition or erosion) marking the Middle–Lower Cambrian boundary.
	Hardyston Quartzite (Ch)	**Ch** is 30 m (100 ft) of gray quartzite, quartz-pebble conglomerate, arkosic sandstone, silty shale, and jasper. Weathered outcrops appear brown. Jasper is yellowish brown and iron stained. High erosion resistance.	**Slope movements**—quartzites are prone to rockfall when undercut by less-resistant units on slopes.	None documented.	**Appalachian mountain building and the assembly of Pangaea**—originally deposited as beach and tidal-flat sands along the Iapetus Ocean. Deformed during the Taconic and Alleghany orogenies.

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Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
MIDDLE PROTEROZOIC	Venite (Ymv)		**Ymv** is a composite unit of amphibolite containing abundant veins, lenses, and irregular bodies of albite-oligoclase granite. **Ymv** minerals include amphibole, albite and oligoclase (plagioclase), and quartz. May be an amphibolite-rich phase of the Losee Metamorphic Suite. Erosion resistance is moderately high.	None documented.	None documented.	**Ancient mountain building and Iapetus Ocean formation**—Metamorphic rocks were deformed and altered during the Grenville Orogeny, which culminated in the assembly of the supercontinent Rodinia. **Yba** and **Ybh** were emplaced during metamorphism of the Grenville Orogeny. Deformation may have also occurred during the Taconic and Alleghany orogenies.
	Byram Intrusive Suite	Microperthite alaskite (Yba)	**Yba** contains medium- to coarse-grained, pink and gray, foliated (banding defined by parallel orientations of alternating light and dark minerals) alaskite. **Yba** contains microperthite, quartz, and oligoclase. Erosion resistance is moderately high.	None documented.		
		Hornblende granite (Ybh)	**Ybh** is medium- to coarse-grained, gray and pink granite. Some portions of **Ybh** are foliated (banding defined by parallel orientations of alternating light and dark minerals). **Ybh** commonly contains interlayers and bands of **Ya**. **Ybh** contains microperthite, quartz, oligoclase, and hornblende. **Ybh** has layers that reached temperatures sufficient to partially melt them into migmatites (particularly interlayers of **Ya**). Erosion resistance is moderately high.			
	Marble (Ymr)		**Ymr** contains dolomite and calcite marble. The unit is highly weathered to serpentinite, tremolite, and talc. contains marble, serpentinite, tremolite, and talc.	**Slope movements**—calcareous (marble) materials within **Ymr** and **Yq** are soluble. Weathered layers of this unit may render it unstable on slopes. Talc is an extremely soft mineral. In areas where unweathered **Yq** is undercut, the potential exists for rockfall.		
	Quartz-plagioclase-epidote-biotite gneiss (Yg)		**Yq** appears light gray and coarse grained in massive to layered exposures. This predominantly calc-silicate rock is associated with marble (metamorphosed carbonates; see **Ymr**). **Yq** minerals include quartz, plagioclase feldspar, epidote, and biotite. Erosion resistance is moderately high.			
	Potassic feldspar gneiss (Yk)		**Yk** consists of fine- to medium-grained, gray and pink gneiss with lesser amounts of granofels. Foliation, or banding defined by parallel orientations of alternating light and dark minerals, is poorly to fairly developed in this unit. Some interlayers of feldspathic quartzite occur locally. **Yk** minerals include quartz, potassic (contains potassium) feldspar, biotite, magnetite, and, less commonly, garnet and/or sillimanite. Mineral assemblages of this unit reflect the amount of heat and/or pressure present during metamorphism. Erosion resistance is moderately high; it is very high for quartzite.	None documented.		
	Oligoclase-quartz gneiss (Ylo)		**Ylo** is medium-grained, light-greenish-gray, poorly foliated (bands defined by parallel orientations of alternating light and dark minerals), granoblastic gneiss and, less commonly, granofels. Some interlayers of amphibolite (see **Ya**) occur in this unit. **Ylo** minerals include oligoclase, quartz, biotite, magnetite, and chloritized (weathered and altered) augite. **Ylo** is likely a metamorphosed (changed by pressure and heat) quartz keratophyre. Erosion resistance is moderately high.			
	Amphibolite (Ya)		**Ya** is fine- to medium-grained, gray to nearly black amphibolite. **Ya** minerals include hornblende and andesine. Some areas also contain augite, hypersthene, or biotite. **Ya** is mostly a metasedimentary rock interlayered with marble (see **Ymr**) and other calcareous and quartzo-feldspathic (rich in quartz and feldspar) metasedimentary rocks. Erosion resistance is moderately high.	**Slope movements**—calcareous (marble) interlayers within **Ya** are soluble. In areas where unweathered **Ya** is undercut, the potential exists for rockfall.		