Bedrock Map Unit Properties Table: Morristown National Historical Park

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Issues	Geologic History
JURASSIC (Lower)	Boonton Formation (Jb) Boonton Formation, quartz-pebble conglomerate (Jbcq)	**Jb** contains interlayered, reddish-brown to purple, fine-grained sandstone, siltstone, and mudstone. Sandstone commonly contains mica flakes. Siltstone and mudstone occur in sequences, with grain size fining upward in each layer. The lower beds of the unit contain partly dolomitic siltstone and shale. **Jbcq** is distinctive quartz-pebble conglomerate present as interlayers with sandstone, siltstone, and shale of **Jb** near Morristown. Individual conglomeratic beds are about 0.5 m (1.6 ft) thick. **Jb** is up to 500 m (1,640 ft) thick. **Jb** is mapped within park boundaries at the Washington's Headquarters unit.	**Bedrock Features**—**Jb** and **Jbcq** contain upward-fining sequences, mudcracks, symmetrical ripple marks, burrows, and pseudomorphs of halite (salt), gypsum, and glauberite. **Paleontological Resources**—Sandstone layers near the middle and upper parts of the unit may contain carbonized plant remains and reptile footprints.	None reported.	**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jb** and **Jbcq** were deposited in a long narrow graben (fault-bounded valley) that opened as the supercontinent Pangaea broke apart during the Early Mesozoic. **Jb** is the youngest unit of the Newark Supergroup in New Jersey.
	Hook Mountain Basalt (Jh)	**Jh** is light– to dark–greenish-gray basalt. The primary mineral constituents are plagioclase, clinopyroxene, and iron-titanium oxides, such as magnetite and ilmenite. Two major flows compose **Jh**, with a maximum thickness of 110 m (360 ft). **Jh** is relatively resistant to erosion and underlies some low, strategic ridges southeast of Morristown.	**Bedrock Features**—**Jh** is amygdaloidal (contains mineral-filled bubbles or vesicles). Small spherical to tubular cavities represent gas-escape vesicles that formed while lava was molten. They are commonly filled with zeolite minerals or calcite.		**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jh** is one of a series of basaltic lava flows that accompanied crustal extension during the breakup of Pangaea. Thinning of Earth's crust allowed molten material to reach the surface.
	Towaco Formation (Jt) Towaco Formation, conglomerate and sandstone facies (Jtc)	**Jt** consists of reddish-brown to purple, fine- to medium-grained micaceous sandstone, siltstone, and silty mudstone. The rocks occur in 1–3-m (3–10-ft) sequences, with grain size fining upward in each layer. **Jtc** is conglomerate and conglomeratic sandstone containing quartzite and quartz clasts in light-red to brown silt. **Jtc** interfingers with **Jt** locally. Maximum thickness of units is about 380 m (1,250 ft).	**Bedrock Features**—**Jt** and **Jtc** contain upward-fining sequences, cross laminations, and bioturbated beds. Layers of **Jc** in contact with **Jh** flows were thermally metamorphosed into hornfels. **Paleontological Resources**—Calcareous siltstone and mudstone interlayers contain pollen, fish, and dinosaur tracks.		**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jt** and **Jtc** were deposited in a long narrow graben (fault-bounded valley) that opened as the supercontinent Pangaea broke apart during the Early Mesozoic.
	Preakness Basalt (Jp) Preakness Basalt, sandstone and siltstone (Jps)	**Jp** contains dark–greenish-gray to black, very fine-grained, dense, hard basalt. The primary mineral constituents are intergrown plagioclase and clinopyroxene. Three major flows compose **Jp**, with thickness ranging from 250 to 320 m (820–1,050 ft). A thin (2–8-m [7–26-ft]) bed of siltstone, **Jps**, separates the lower two flows of **Jp**. **Jp** and **Jps** are relatively resistant to erosion and underlie Second Watchung Mountain, southeast of Morristown.	**Bedrock Features**—**Jp** is amygdaloidal (contains mineral-filled bubbles or vesicles). Small spherical to tubular cavities represent gas-escape vesicles that formed while lava was molten. They are commonly filled with zeolite minerals or calcite. Abundance of amygdules increases near contacts between flows. Radiating slender columns, formed by overall shrinkage while cooling, are abundant in the highest flow.		**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jp** is one of a series of basaltic lava flows that accompanied crustal extension during the breakup of Pangaea. Thinning of Earth's crust allowed molten material to reach the surface. **Jps** represents a temporary cessation of volcanism when deposition of siltstone took place.
	Feltville Formation (Jf)	**Jf** consists of interlayered brownish-red to gray, fine- to coarse-grained sandstone; gray and black, coarse siltstone; and silty mudstone. Two 3-m- (10-ft-) thick layers of thin, black carbonaceous (carbon-bearing) limestone and gray, calcareous (calcium carbonate-bearing) siltstone occur near the base of **Jf**. Some thin gray to black siltstone and mudstone sequences occur near the top of **Jf**. Maximum thickness of this unit is 155 m (510 ft).	**Bedrock Features**—**Jf** contains upward-fining sequences, cross laminations, and bioturbated beds. Layers of **Jf** in contact with **Jp** flows were thermally metamorphosed into hornfels. **Paleontological Resources**—Carbonaceous limestone and calcareous siltstone interlayers contain abundant fish, reptile, arthropod, and diagnostic plant fossils.		**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jf** was deposited in a long narrow graben (fault-bounded valley) that opened as the supercontinent Pangaea broke apart during the Early Mesozoic.
	Orange Mountain Basalt (Jo)	**Jo** is dark–greenish-gray to black, fine-grained basalt. The primary mineral constituents are calcic plagioclase and clinopyroxene. Three major flows, separated by weathered zones or minor siltstone or mixed volcanic/sediment rocks, compose **Jo**, with a maximum thickness of 182 m (597 ft). **Jo** is relatively resistant to erosion and underlies First Watchung Mountain, southeast of Morristown.	**Bedrock Features**—**Jo** is amygdaloidal (contains mineral-filled bubbles or vesicles). Small spherical to tubular cavities represent gas-escape vesicles that formed while lava was molten. They are commonly filled with zeolite minerals or calcite. Abundance of amygdules increases near contacts between flows. Curvilinear and columnar joints, formed by overall shrinkage while cooling, are abundant in the lowest and middle flows. The uppermost flow has pillow structures at its base and pahoehoe (ribbony) flow structures near the top.		**Breakup of Pangaea, Crustal Extension, and Volcanism**—**Jo** is one of a series of basaltic lava flows that accompanied crustal extension during the breakup of Pangaea. Thinning of Earth's crust allowed molten material to reach the surface.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Issues	Geologic History
Lower JURASSIC and Upper TRIASSIC	Passaic Formation (JTRp) Passaic Formation, sandy mudstone (JTRpms) Passaic Formation, conglomerate and sandstone facies (JTRpsc)	**JTRp** is reddish-brown to purple to grayish-red siltstone and shale with a maximum thickness of 3,600 m (11,810 ft). **JTRp** has several members, including: (1) reddish-brown to red, massive, silty to sandy mudstone and siltstone (**JTRpms**) and (2) brownish-red pebble conglomerate and medium- to coarse-grained, feldspathic sandstone and micaceous siltstone (**JTRpsc**). **JTRpsc** is up to 1,100 m (3,610 ft) thick.	**Bedrock Features**—**JTRpms** contains ripple marks, cross laminations, desiccation features, mudcracks, burrows, root casts, and bioturbated beds. Layers of **JTRpms** in contact with **Jo** flows were thermally metamorphosed into hornfels. **JTRpsc** contains 0.5–2.5- (2–8-ft-) thick upward-fining sequences, ripple marks, pebble layers, desiccation cracks, and root casts. **Paleontological Resources**—**JTRpms** and **JTRpsc** contain some fossils, burrows, and root casts.	None reported.	**Breakup of Pangaea, Crustal Extension, and Volcanism**—**JTRp**, **JTRpms**, and **JTRpsc** were deposited in a long narrow graben (fault-bounded valley) that opened as the supercontinent Pangaea broke apart during the Early Mesozoic.
ORDOVICIAN (Middle)	Jutlan Klippe Sequence unit B (Ojtb)	**Ojtb** is a heterogeneous mix of red, green, tan, and gray shale; interlayered dolomite and shale; interlayered fine-grained greywacke siltstone with beds or lenses of sandstone; light-gray to pale pinkish-gray quartzite; and interlayered fine-grained, thin-bedded limestone and red and green shale. Thickness ranges from 460 to 500 m (1,500–1,800 ft).	**Bedrock Features**—Limestone beds resemble conglomerates because they are disrupted, broken into rounded blocks (boudinage) in situ, and surrounded by shale beds. Graywacke is a sedimentary rock characterized by hardness, dark color, and poorly sorted angular grains of quartz and feldspar mixed with small rock or lithic fragments set in a compact, clay-fine matrix. Graywackes may form in submarine landslides where mixtures of dissimilar sediment sizes occur—immature sedimentary rocks. **Paleontological Resources**—Graptolites, conodonts, brachiopods.		**Appalachian Mountain Building**—Unit was highly deformed and transported along a thrust fault during the Paleozoic orogenies along the eastern margin of North America.
CAMBRIAN (Middle and Lower)	Leithsville Formation (Cl)	**Cl** consists of light- to dark- and olive-gray, fine- to medium-grained, thin- to medium-bedded dolomite in the upper layers. These layers grade downward into medium-gray to yellow to pink dolomite and dolomitic sandstone, siltstone, and shale. The lower layers of the unit are gray, medium-grained, medium-bedded dolomite with quartz sand stringers and lenses near the base. This unit is eroded and thickness ranges from 0 to 56 m (0–185 ft).	None reported.		**Longstanding Marine Margin**—**Cl** has a gradational contact with underlying **Ch**, indicating more or less continuous deposition.
CAMBRIAN (Lower)	Hardyston Quartzite (Ch)	**Ch** consists of light- to medium-gray and bluish conglomeratic sandstone. Some layers are pebble conglomerates, whereas others are finer-grained quartzite, arkosic, or dolomitic sandstone. Unit thickness ranges from about 0 to 9 m (1–30 ft).	**Bedrock Features**—Quartz pebbles in **Ch** are white and up to 2.5 cm (1 in) in diameter.		**Longstanding Marine Margin**—**Ch** has a gradational contact with overlying **Cl**, indicating more or less continuous deposition. The lower contact of **Ch** is unconformable, indicating a period of erosion or nondeposition.
LATE PROTEROZOIC ERA	Diabase dike (Zd)	Diorite is a gray to dark-gray to greenish intrusive igneous rock with moderate silica content. Primary minerals include plagioclase feldspar, biotite, hornblende, and/or pyroxene. Diorites may also contain small amounts of quartz, microcline, and olivine. **Zd** was mapped as linear dikes or intrusive bodies that cut across pre-existing bedrock structures, but no description of the unit is available.	None reported.		**Rifting of Rodinia and Opening of the Iapetus Ocean**—Discrete intrusions of igneous rocks, such as **Zd**, accompanied the rifting of Rodinia during crustal extension.

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Age	Map Unit (Symbol)		Geologic Description	Geologic Features and Processes	Geologic Issues	Geologic History
MIDDLE PROTEROZOIC ERA	Lake Hopatcong Intrusive Suite	Pyroxene granite (Ypg)	**Ypg** is greenish-gray, medium- to coarse-grained, massive, gneissic to scantly foliated granite with some monzonite, quartz monzodiorite, or granodiorite phases locally (for brief explanation, see http://en.wikipedia.org/wiki/QAPF_diagram [accessed 19 August 2014]). **Ypg** weathers to gray, buff, or white. Primary mineral constituents are microcline, quartz, oligoclase, and clinopyroxene. Secondary minerals include titanite, magnetite, apatite, and some pyrite. **Ypg** contains thin amphibolite bodies (see **Ya**).	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ypg** include foliation.	None reported.	**Grenville Orogeny and the Supercontinent Rodinia**—**Ypg**, **Yba**, and **Ybh** were part of a series of igneous intrusions during the Grenville Orogeny, just prior to its peak metamorphic intensity in the area of present-day New Jersey. They are among the youngest basement rocks exposed in the New Jersey Highlands.
	Byram Intrusive Suite	Microperthite allanite (Yba)	Alaskite is a type of igneous (and/or metamorphic) rock, typically light colored, composed mainly of quartz and feldspar, with little or no dark-colored minerals. **Yba** was metamorphosed from granite to gneiss with scant foliation textures. In fresh exposures, **Yba** is pinkish gray to white, medium to coarse grained, and appears pink to buff on weathered outcrops. Primary mineral constituents are microcline (microperthite, a potassium feldspar), quartz, and oligoclase.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Yba** include scant foliation.		
		Hornblende granite (Ybh)	**Ybh** is pinkish-white to gray, medium- to coarse-grained, somewhat foliated granite and granitic gneiss. Primary mineral constituents include microcline, microperthite, quartz, oligoclase, and hornblende. Small bodies of pegmatite and amphibolite (see **Ya**) are present locally within **Ybh**. **Ybh** is mapped within park boundaries at the Fort Nonsense, New Jersey Brigade Encampment Area, and Jockey Hollow Encampment Area units.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ybh** include foliation. **Ybh** has a U-Pb age of approximately 1,090 million years.	**Disturbed Lands**—Minerals in Mesoproterozoic units were targets of local mining. Several abandoned mine land sites occur in the park.	
	Potassic feldspar gneiss (Yk)		**Yk** is pinkish-white to gray, fine- to medium-grained, moderately foliated gneiss with lesser amounts of granofels (a coarse-grained, non-foliated metamorphic rock). Primary mineral constituents include quartz, microcline, microperthite, and some biotite, garnet, sillimanite, and opaque (dark) minerals. Weathered outcrops of **Yk** appear light gray to pinkish to buff.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Yk** include foliation.	None reported.	**Grenville Orogeny and the Supercontinent Rodinia**—**Yk**, **Yb**, **Ymh**, **Ymp**, **Yp**, and **Yf** (also some **Ya** units) are part of a series of metasedimentary (supracrustal) rocks deposited in a basin between compressive episodes of the Grenville Orogeny. **Yf** was metamorphosed limestone, perhaps originally part of a carbonate platform in a shallow marine setting.
	Biotite-quartz-feldspar gneiss (Yb)		Gneiss is a metamorphic rock in which minerals are segregated into bands of alternating composition—commonly marked by bands of flaky or elongate minerals. **Yb** consists of gray to tan or greenish-gray, fine- to medium–coarse-grained gneiss with variable foliation textures and compositions. **Yb** weathers to gray or rusty color. Primary mineral constituents are oligoclase, microcline, quartz, and biotite. Secondary minerals include garnet, graphite, sillimanite, and opaque (dark) minerals. **Yb** is mapped within park boundaries at the Fort Nonsense, New Jersey Brigade Encampment Area, and Jockey Hollow Encampment Area units.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Yb** include layering and foliation. **Paleontological Resources**—Graphite deposits in **Yb** may represent the remains of algal mats or other metamorphosed organic material.	**Disturbed Lands**—Minerals in Mesoproterozoic units were targets of local mining. Several abandoned mine land sites occur in the park.	

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Issues	Geologic History
MIDDLE PROTEROZOIC ERA	Hornblende-quartz-feldspar gneiss (Ymh)	**Ymh** is pinkish-white to gray, fine- to medium-grained, massive to moderately well-layered gneiss. Primary mineral constituents include microcline, quartz, oligoclase, hornblende, and magnetite, with some garnet and biotite locally. **Ymh** weathers to pinkish gray to buff. **Ymh** is mapped within park boundaries at the New Jersey Brigade Encampment Area unit.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ymh** include foliation and layering.	**Disturbed Lands**—Minerals in Mesoproterozoic units were targets of local mining. Several abandoned mine land sites occur in the park.	**Grenville Orogeny and the Supercontinent Rodinia**—**Yk**, **Yb**, **Ymh**, **Ymp**, **Yp**, and **Yf** (also some **Ya** units) are part of a series of metasedimentary (supracrustal) rocks deposited in a basin between compressive episodes of the Grenville Orogeny. **Yf** was metamorphosed limestone, perhaps originally part of a carbonate platform in a shallow marine setting.
	Clinopyroxene-quartz-feldspar gneiss (Ymp)	**Ymp** is white to pink to gray, fine- to medium-grained, massive to moderately well-layered gneiss. Primary mineral constituents include microcline, quartz, oligoclase, and clinopyroxene, with some epidote, biotite, titanite, and opaque (dark) minerals locally. **Ymp** is commonly interlayered with amphibolite (see **Ya**) or pyroxene amphibolite. **Ymp** weathers to pink or buff.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ymp** include foliation and layering.	None reported.	
	Pyroxene gneiss (Yp)	**Yp** is greenish-gray, fine- to medium-grained, well-layered gneiss. Primary mineral constituents include oligoclase, clinopyroxene, some quartz, and scant opaque (dark) minerals and titanite. **Yp** is commonly interlayered with pyroxene amphibolite or marble (see **Yf**). **Yp** weathers to white or tan.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Yp** include foliation and layering.		
	Franklin Marble (Yf)	Marble is a non-foliated (non-banded) metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite. Marble is commonly metamorphosed limestone. **Yf** is white to gray to pinkish-orange, coarse- to fine-crystalline calcite marble. Accessory minerals include graphite, phlogopite, chondrodite, clinopyroxene, and serpentinite. Pods and layers of metaquartzite and clinopyroxene- and hornblende-rich rock occur locally. Talc and asbestos mines near Easton, Pennsylvania, are within **Yf**.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. **Yf** contains the Franklin and Sterling Hill zinc ore bodies. **Paleontological Resources**—Graphite deposits in **Yf** may represent the remains of algal mats or other metamorphosed organic material.		
	Losee Metamorphic Suite (basement rocks): Amphibolite (Ya)	Amphibolite is a type of metamorphic rock composed mainly of amphibole (dark) and plagioclase feldspar (light), with little or no quartz. Amphibolite is typically dark and heavy, with a weakly foliated (banded appearance) or schistose (flaky) texture. Small black and white crystals give the rock a salt-and-pepper appearance. **Ya** is gray to grayish-black, medium-grained amphibolite. Biotite and clinopyroxene are minor mineral constituents. **Ya** is mapped within park boundaries at the Jockey Hollow Encampment Area unit.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia.	**Disturbed Lands**—Minerals in Mesoproterozoic units were targets of local mining. Several abandoned mine land sites occur in the park.	**Grenville Orogeny and the Supercontinent Rodinia**—**Ya**, **Yd**, **Yh**, **Ylb**, and **Ylo** are part of a series of metamorphic rocks that were part of the early eastern margin of North America. Initial metamorphism and deformation of these rocks occurred during the Grenville Orogeny, more than 1 billion years ago, during the formation of the supercontinent Rodinia. **Ya** stems from the metamorphism of a variety of sources in the park area, including volcanic rocks, sediments, and gabbros (low-silica igneous rocks).
	Losee Metamorphic Suite (basement rocks): Hypersthene-quartz-oligoclase gneiss (Yh)	**Yh** consists of greenish-gray to brown, medium-grained gneiss with strong foliation textures and layering. **Yh** weathers to gray or tan and has a greasy sheen. Primary mineral constituents are andesine or oligoclase, quartz, clinopyroxene, hornblende, hypersthene, and scant biotite. **Yh** is commonly layered with amphibolite (see **Ya**) and plagioclase-quartz gneiss. **Yh** is mapped within park boundaries at the Fort Nonsense unit.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Yh** include strong foliation and layering.		

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Age	Map Unit (Symbol)		Geologic Description	Geologic Features and Processes	Geologic Issues	Geologic History
MIDDLE PROTEROZOIC ERA	Losee Metamorphic Suite (basement rocks)	Diorite (Yd)	**Yd** is greenish-gray to brown, medium- to coarse-grained, massive diorite. Some amphibolite layers (**Ya**) occur throughout the unit. Outcrop appearance is gray to tan with a greasy sheen. Primary minerals include andesine or oligoclase (plagioclase feldspars), clinopyroxene, and hypersthene, with some biotite and magnetite. **Yd** is mapped within park boundaries at the Jockey Hollow Encampment Area unit.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia.	**Disturbed Lands**—Minerals in Mesoproterozoic units were targets of local mining. Several abandoned mine land sites occur in the park.	**Grenville Orogeny and the Supercontinent Rodinia**—**Ya**, **Yd**, **Yh**, **Ylb**, and **Ylo** are part of a series of metamorphic rocks that were part of the early eastern margin of North America. Initial metamorphism and deformation of these rocks occurred during the Grenville Orogeny, more than 1 billion years ago, during the formation of the supercontinent Rodinia. **Ya** stems from the metamorphism of a variety of sources in the park area, including volcanic rocks, sediments, and gabbros (low-silica igneous rocks).
		Quartz-oligoclase gneiss (Ylo)	**Ylo** is greenish-gray, medium- to coarse-grained, moderately layered to somewhat foliated gneiss and some granofels. **Ylo** weathers to white. Primary mineral constituents are quartz, andesine or oligoclase, and locally biotite, clinopyroxene or hornblende. **Ylo** contains thin amphibolite layers (see **Ya**). **Ylo** is mapped within park boundaries at the Fort Nonsense, New Jersey Brigade Encampment Area, and Jockey Hollow Encampment Area units.	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ylo** include foliation and layering.		
		Biotite-quartz-oligoclase gneiss (Ylb)	**Ylb** consists of gray to greenish-gray, fine- to coarse-grained, massive to moderately layered and foliated gneiss. **Ylb** weathers to white or light gray. Primary mineral constituents are andesine or oligoclase, quartz, biotite, and some local garnet. **Ylb** is commonly interlayered with amphibolite (see **Ya**).	**Bedrock Features**—Old metamorphic rocks are from a variety of original sources that were deformed, fragmented, and transported over millennia. Metamorphic textures of **Ylb** include foliation and layering.		