Map Unit Properties Table: Hopewell Culture National Historical Park

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
Surficial Units					
QUATERNARY (Recent)	Alluvium (Qal)	In general, alluvium is a mixture of sorted mud, silt, sand, and gravel that is deposited in a riverine environment. In areas of relatively rapid flow, coarser gravels and sands dominate the deposits, whereas areas of stagnant water or slower flow tend to concentrate muds and silts. Mapped within each area of the park.	*Flooding and fluvial processes*—units are associated with active, migrating river channels, floodplains, and riparian zones. Units are prone to flooding and unstable banks. Riverbank erosion is a concern for park sites, particularly the Hopewell Mound Group. Access road to Hopeton quarry is utilized when Hopeton Road floods. Riprap installed at Mound City Group in 1980s. *Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. The Hopeton quarry (Hopeton Earthworks site) is located partially on **Qal**. Abandoned sand and gravel pits are located in Mound City Group and High Bank Works. *Slope processes*—blocks of earth continue to slump into North Fork Paint Creek at Hopewell Mound Group and can be an issue throughout the park where riverbanks are eroding.	*Geologic connections to park stories*—Hopewell people generally avoided active floodplains for mound and earthwork construction, instead choosing outwash terraces less prone to annual flooding. Hopewell habitation sites have been recorded on **Qal** units. Archeological deposits may be deeply buried in **Qal** settings. Mound construction material may have been sourced from these units.	*Erosion and Establishment of the Modern Landscape*—**Qal** is the youngest mapped unit on the park's landscape and reflects modern, active geomorphological processes.
	Alluvial terrace (Qalt)	Alluvial terraces are elongated treads or platforms that flank the sides of floodplains and river valleys and are separated from adjacent landforms by steeper rises or slopes. In general, terraces parallel the river channel and represented remnants of earlier floodplains that existed when the river was flowing at a higher elevation. Because of this manner of formation, alluvial terraces tend to contain the same types of deposit as alluvium.			*Erosion and Establishment of the Modern Landscape*—**Qalt** reflects higher-elevation riverine flow. Changes in local elevation throughout the Holocene may be due to climatic change or changes in base level, which in turn increase headward erosion and flow velocity.
QUATERNARY (Pleistocene, Wisconsinan glaciation)	Lacustrine deposit (Wl)	Lacustrine deposits are associated with sedimentation into lakes and other stagnant water. Deposits tend to be fine grained and may form varves that represent annual cycles of thin, fine-grained deposits from winter followed by thicker, coarser-grained deposits resulting from an influx of flow during spring and summer runoff.	*Disturbed lands and mineral resources*—coarse sand, if present, may be target of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—lacustrine deposits from ice-dammed glacial lakes. *Geologic connections to park stories*—clay-rich lacustrine deposits may have provided mound construction materials. Different clay colors may have influenced placement. Clay-rich lacustrine deposits were likely exploited as raw material for ceramic manufacture. *Paleontological resources*—lacustrine deposits often contain fossil pollen and other organic material. Eighteen species of mollusk fossil are present in various lacustrine units associated with the Wisconsinan glaciation.	*Ice Age Glaciations*—Lacustrine deposits from the Wisconsinan glaciation record the presence of lakes that formed in front of melting glacial ice.
	Bainbridge Outwash (Wob)	**Wob** consists of a series of fine-grained silt terraces at an intermediate elevation of 235 to 245 m (770 to 800 ft) in the Paint Creek Valley. These deposits are at least 3 m (10 ft) thick. The sediments have an easterly gradient of about 2 m/km (12 ft/mi).	*Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—outwash and lacustrine deposits (silty **Wob** suggests ice-dammed glacial lake near Bainbridge). *Geologic connections to park stories*—although no park site is located on **Wob**, Hopewell Culture mound and earthwork sites throughout the area tend to be located on outwash terraces.	*Ice Age Glaciations*—The Bainbridge Outwash likely formed at the same time as the Boston Till, about 21,000 years ago. The presence of **Wob** demonstrates that the earliest Late Wisconsinan ice sheet did not advance into the western end of Paint Creek Valley. Fine-grained, silty **Wob** was deposited into Glacial Lake Bainbridge, formed by ice damming of a local stream.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Pleistocene, Wisconsinan glaciation)	Kingston Outwash (Wok)	**Wok** contains typical outwash deposits of sand and silt, nearly indistinguishable from other outwashes east of the Scioto River save for its elevation, outwash gradient, loess (wind-blown silt) cover, and distinctive (Ockley) soil profile. In the Paint Creek area, **Wok** has a distinctive composition with no loess cover and 50% fewer crystalline pebbles and 11% more carbonate composition with a lower limestone/dolomite ratio than all other outwash units within Ross County. Part of **Wok** is a kame terrace with a few shallow kettles. **Wok** is mapped within Hopeton Earthworks and Seip Earthworks.	*Flooding and fluvial processes*—unit is mapped primarily along Paint Creek Valley and North Fork Paint Creek, where river reaches the terraces. Riverbank erosion is a concern for park sites, particularly Hopewell Mound Group. *Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—outwash, deposited by meltwater streams; kames, mound-like ridges of sand or gravel; kettles, small depressions (can subsequently be filled by lakes) where blocks of ice were left behind. *Geologic connections to park stories*—Hopewell Culture mound and earthwork sites are located on outwash terraces, including **Wok**. *Paleontological resources*—kettle lakes may preserve fossil pollen records and other organic remains.	*Ice Age Glaciations*—**Wok** is the highest-level Late Wisconsinan outwash in the Scioto River Valley, 14 m (45 ft) higher than the next highest terrace, **Woc**. It formed approximately 18,000 years before present. **Wok** may have been deposited during the cutoff of the Teays River Valley by the Newark River. If so, then a bedrock constriction in the cutoff area controlled the absence of **Wok** south of Rupels. A lack of loess cover in Paint Creek Valley suggests that the source of the loess was the main Scioto River Valley; wind transported the fine, silt deposits eastward.
	Circleville Outwash (Woc)	**Woc** contains typical outwash deposits of sand and silt, nearly indistinguishable from other outwashes of the Scioto River Valley save for its elevation and distinctive leaching depth (75 cm [30 in]) of the soil profile. **Woc** is mapped within Hopeton Earthworks, Mound City Group, Hopewell Mound Group, and High Bank Works.	*Flooding and fluvial processes*—unit is mapped primarily along Scioto River and North Fork Paint Creek, where rivers reach the terraces. Riverbank erosion is a concern for park sites, particularly at Mound City Group where trees have been planted to stabilize bank erosion. *Disturbed lands and mineral resources*—sand and gravel quarries in Ross County target outwash deposits, such as **Woc**. The Hopeton quarry (Hopeton Earthworks site) is partially located on **Woc**. Access road to Hopeton quarry is utilized when Hopeton Road floods. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—outwash, deposited by meltwater streams; braided channels of **Woc** are visible in fields near the Veterans Hospital, west of Ohio Route 104. *Geologic connections to park stories*—Hopewell Culture mound and earthwork sites are located on outwash terraces, including **Woc**.	*Ice Age Glaciations*—Late Wisconsinan, intermediate-elevation **Woc** terraces are the most extensive Wisconsinan outwash deposits in Ross County. They mark two distinct positions of the ice margin during outwash deposition: 1) 17,000 years before present at the Reesville Moraine (**Wi3**, **Wg3**, **We3**), with a maximum position near Roxabell; and 2) 16,800 years before present at the Yellowbud and Marcy moraines (**Wg4** and **We4**) in the Scioto River Valley. Final, post-Illinoian breaching of the Deep-Stage Newark River cutoff and the establishment of the present course of the Scioto River may have happened as late as during the deposition of the Kingston Outwash (**Wok**), about 18,000 years before present.
	Worthington Outwash (Wow)	**Wow** contains outwash deposits of silt, sand, and gravel that are typical for the region; however, in some areas, the limestone/dolomite ratio is slightly higher. Large areas of **Qal** and **Qalt** are underlain by **Wow** sand and gravel.	*Flooding and fluvial processes*—unit is mapped primarily along Scioto River north and south of the park. Riverbank erosion is a potential issue; although erosion of **Wow** does not currently affect park resources, other Hopewell sites and mounds may be present. *Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—outwash, deposited by meltwater streams.\ *Geologic connections to park stories*—Hopewell Culture mound and earthwork sites are located on outwash terraces, although no current park site is located on **Wow**.	*Ice Age Glaciations*—**Wow** has the lowest Late Wisconsinan outwash elevation in the Scioto River Valley. Outcrops of **Wow** stretch some 80 km (50 mi) south of their source in southern Delaware County. The gradients of **Wow** and **Woc** nearly parallel the present gradient of the Scioto River north of Chillicothe. South of Chillicothe, the outwash levels remain parallel, but decrease in gradient relative to the river. This gradient anomaly is related to the narrowing of the Scioto River by the bedrock uplands and higher outwash terraces. During glacial retreat, the Appalachian Plateau escarpment and Higby Outwash (**Io**) terraces confined the Late Wisconsinan meltwater to a narrower channel, in contrast with the valley north of Chillicothe.
	Erosional terrace outwash (Wot)	**Wot** deposits arise from the erosion of existing glacial outwash terraces to form localized outwash deposits. Outwash typically consists of silt, sand, and gravel deposits.	*Flooding and fluvial processes*—riverbank erosion is a potential issue; although erosion of **Wot** does not currently affect park resources, other Hopewell sites and mounds may be present. *Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—outwash, deposited by meltwater streams. *Geologic connections to park stories*—Hopewell Culture mound and earthwork sites are located on outwash terraces, although no current park site is located on **Wot**.	*Ice Age Glaciations*—**Wot** records the erosion of outwash materials during Wisconsinan glacial advances and retreats.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Pleistocene, Wisconsinan glaciation)	Kames, kame terraces, eskers, drift, and related end moraines	Caesar Till (Lattaville Moraine) (Wi2)	Caesar Till comprises three till units separated by thin outwash zones. Locally, the till is 5 m (18 ft) of blue-gray to yellow-brown, calcareous, compact, unoxidized mixtures of clay, sand, and gravel in unsorted deposits. Extent of this unit follows the location of the Lattaville Moraine, a nearly continuous 0.8- to 5.6-km- (0.5- to 3.5-mi-) wide crescentic end moraine extending for 32 km (20 mi) from Adelphi to Humboldt. Locally, this moraine displays irregular, hummocky topography. Thickness of the moraine ranges from 8 to 64 m (26 to 210 ft). Sand and gravel zones within the till-rich moraine are less than 1 to 7 m (1 to 25 ft) thick.	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping when exposed on a slope.	*Glacial features*—till, deposited directly by glacier; moraines, mark extent of glacier; kames and eskers, deposited beneath or near glacier. *Geologic connections to park stories*—as with many surficial units in the area, **Wi2** and **Wi3** may contain Hopewell or other archeological resources.	*Ice Age Glaciations*—Spruce logs from the Caesar Till yielded ages of 17,980 and 16,590 years before present. These lumped units are all associated with minor oscillations of the same Late Wisconsinan ice sheet. The Lattaville Moraine is composed primarily of Caesar Till. The trace of the moraine parallels the northeast to southwest–trending Appalachian Plateau escarpment, demonstrating this local structural control on glacial processes. The Lattaville Moraine formed approximately 18,000 years before present. *Ice Age Glaciations*—In north-central and northwestern Ross County, Darby Till is the surface till north of the distal edge of the Reesville Moraine. The Late Wisconsinan Darby Till also caps the recessional Yellowbud Moraine (**Wg4**). The Reesville Moraine is the distal boundary of glacial drift associated with the readvance of the Scioto Sublobe. The Reesville Moraine dates to approximately 17,300 years before present. Local topography strongly controlled the readvancing ice sheet, concentrating the ice penetration into areas of lowest relief. In general, the Appalachian Plateau escarpment forced ice to deflect toward the southwest.
		Darby Till (Reesville Moraine) (Wi3)	The Darby Till is locally 7 m (22 ft) of homogenous, pebbly, dark-gray, well-jointed till. This till lacks a loess cover and is leached to a depth of 61 cm (24 in). Some secondary clay deposits are developed in the joints. The Reesville Moraine is poorly defined in Ross County due to its lack of topographic expression. In other areas, the moraine is a well-defined arcuate accumulation of drift with characteristic hummocky topography. The lack of these features in Ross County seems anomalous.			
	Ice-contact feature overlain by till, drift, and related end moraines, Caesar Till (Lattaville Moraine) (Wit2)		In general, the term "ice contact" is used to differentiate glacial sediments deposited at the ice contact (usually dumped in place when the ice melts) from glacial-fluvial deposits associated with water flowing beneath or from a glacier. A common ice-contact feature is a moraine, an unstratified deposit (mixture of gravel, boulders, and clay) that results from material falling on the glacier or being pushed by the ice. See also the description of **Wi2**.			
	Ground moraine, drift, and related end moraines	Boston Till (Wg1)	Ground moraine associated with the Late Wisconsinan glaciation covers most of northwestern Ross County. Exposures of Boston Till are restricted to tributary valleys of the Paint Creek Valley in elongated (north–south) exposures paralleling the trends of the valleys. They generally abut older, Illinoian ice-contact deposits (**Ii**). Thickness of the Boston Till ranges from 5 to 24 m (15 to 78 ft). It is distinctive from all other till units in Ross County. The Boston Till is generally friable, pebble-rich, and yellowish-brown in outcrop. Carbonate leaching persists to a depth of 81 cm (32 in) and the unit is covered by a loess layer of 38 cm (15 in).	*Disturbed lands and mineral resources*— sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—prone to slumping, with active scarps in southwestern Twin Township.	*Glacial features*—till, deposited directly by glacier; moraines, mark extent of glacier. *Geologic connections to park stories*—as with many surficial units in the area, **Wi3**, **Wg2**, **Wg3**, **and Wg4** may contain Hopewell or other archeological resources.	*Ice Age Glaciations*—The Boston Till marks the maximum advance of the Late Wisconsinan ice sheet; locally, it overlies lacustrine deposits of Illinoian Glacial Lake Bourneville (**Il**). The Boston Till formed approximately 21,000 years before present. The till may have been eroded remnants of older, Illinoian material, but it correlates with mapped Boston Till elsewhere.
		Caesar Till (Lattaville Moraine) (Wg2)	The Caesar Till extends in a 2- to 5-km- (1- to 3-mi-) wide zone from the proximal margin of the Lattaville Moraine to the edge of the Darby Till drift. The mixed clay, silt, sand, and gravel deposits are covered with windblown silt (loess). The thickness of the Caesar Till ground moraine ranges from 0 to 20 m (0 to 64 ft). See also the description of **Wi2**.	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—ground moraine is generally of low relief, except where thin drift overlies bedrock high areas and postglacial stream erosion has created up to 46 m (150 ft) of relief. Such areas may be particularly prone to slope processes, including slumping and sliding.		*Ice Age Glaciations*—The thinness of the Caesar Till ground moraine is related to its location on the high bedrock surface associated with the Appalachian Plateau escarpment margin. It is topographically continuous with the loess-free Darby Till ground moraine (**Wg3**) to the north.
		Darby Till (Reesville Moraine) (Wg3)	Darby Till ground moraine covers the northwestern fifth of Ross County, as a till plain. Depth to bedrock depends on bedrock topography, but ranges from 5 to 38 m (15 to 125 ft). Till includes sand, sand and gravel, and "hardpan" layers. See also the description of **Wi3**.	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.		*Ice Age Glaciations*—In the southwestern part of the Scioto Sublobe (Wisconsinan glacier), where tice movement was most extensive, end moraines formed during pauses in relatively rapid recession. However, stagnation occurred in the area nearer the Appalachian Plateau escarpment, as evidenced by a lack of large end moraines, a deposition of outwash, and an abundance of ice-contact deposits.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)		Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Pleistocene, Wisconsinan glaciation)		Darby Till (Yellowbud Moraine) (Wg4)	The Yellowbud Moraine exhibits typically hummocky topography in north-central Ross County. The end moraine is composed of two distinct moraine types. The southeastern third is kame moraine with rolling topography, developed on ice-contact sand and gravel ranging in thickness from 16 to 32 m (53 to 106 ft). The northwestern two-thirds is typical till moraine, rich in clay, and ranging in thickness from 3 to 12 m (10 to 41 ft).	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—till, deposited directly by glacier; moraines, mark extent of glacier. *Geologic connections to park stories*—as with many surficial units in the area, **Wi3**, **Wg2**, **Wg3**, **and Wg4** may contain Hopewell or other archeological resources.	*Ice Age Glaciations*—The lack of drainage channels or other surface erosion indicators indicates that no till was ever deposited on the southeastern-third, kame-moraine surface. The Yellowbud Moraine was formed in conjunction with a significant short pause of the ice margin during recession from the Reesville Moraine (**Wg3**).
QUATERNARY (Pleistocene, Wisconsinan glaciation)	End moraine, drift, and related end moraines	Caesar Till (Lattaville Moraine) (We2)	End moraines, also called terminal moraines, are unconsolidated mixtures of sediment deposited at the end of a glacier. They typically reflect the morphology or shape of the glacier's terminus. The size and shape of the end moraine are determined by glacial advance, retreat, and/or stagnation. Larger moraines reflect a long-standing glacial position that allowed more material to accumulate. End moraines are categorized into two main types: terminal and recessional. Terminal moraines reflect the maximum advance of the glacier over the landscape, whereas recessional moraines tend to be smaller ridges left in place as the glacier stagnated intermittently during its melt and retreat. Moraines are frequently dissected by outwash streams and other postglacial erosional processes. See also the descriptions of **Wit2**, **Wg2**, and **Wi2**.	Refer to geologic issues of **Wit2**, **Wg2**, **Wi2**, **We2**, **Wi3**, **Wg3**, and **Wg4**.	Refer to geologic features and processes of **Wit2**, **Wg2**, **Wi2**, **We2**, **Wi3**, **Wg3**, and **Wg4**.	Refer to geologic history of **Wit2**, **Wg2**, **Wi2**, **We2**, **Wi3**, **Wg3**, and **Wg4**.
QUATERNARY (Pleistocene, Wisconsinan glaciation)	End moraine, drift, and related end moraines	Darby Till (Reesville Moraine) (We3)	Refer to descriptions of **We2**, **Wi3**, and **Wg3**.			
QUATERNARY (Pleistocene, Wisconsinan glaciation)	End moraine, drift, and related end moraines	Darby Till (Yellowbud Moraine) (We4)	Refer to descriptions of **We2** and **Wg4**.			
QUATERNARY (Pleistocene, Illinoian glaciation)	Lacustrine deposit (Il)		Lacustrine deposits are associated with sedimentation into lakes and other stagnant water. Deposits tend to be fine grained and may form varves that represent annual cycles of thin, fine-grained deposits from winter followed by thicker, coarser-grained deposits resulting from an influx of flow during spring and summer runoff. See also the description of **Wl**.	*Disturbed lands and mineral resources*—coarse sand, if present, may be target of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Glacial features*—lacustrine deposits from ice-dammed glacial lakes. *Geologic connections to park stories*—clay-rich lacustrine deposits may have provided mound construction materials. Different clay colors may have influenced placement. *Paleontological resources*—lacustrine deposits often contain fossil pollen and other organic material. Lacustrine deposits may locally contain fossil mollusks.	*Ice Age Glaciations*—Lacustrine deposits from the Illinoian glaciation record the presence of lakes that formed in front of melting glacial ice.
QUATERNARY (Pleistocene, Illinoian glaciation)	Ice-contact features (kames) (Ii)		Restricted to tributary valleys of Paint Creek Valley, Illinoian kames are generally symmetrical and conical. The kame material is generally well sorted with rudimentary sedimentary structures. Ice-contact deposits have a wide range of grain sizes and may contain glacial erratics up to 1 m (3 ft) in diameter. In general, the pebble composition of **Ii** is characterized by a lower content of total carbonates in comparison with younger deposits.	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County.	*Glacial features*—kames, mounds of material deposited by glacial streams or lakes. Because of their size and morphology, kames are often mistaken for archeological mounds. *Geologic connections to park stories*—kames mapped near Spruce Hill. During the Late Archaic period, people of the Glacial Kame and Red Ochre cultures used glacial kames as cemeteries (ca. 2,500-3,500 years before present).	*Ice Age Glaciations*—The Illinoian kames formed where a fragment of melting Illinoian ice became isolated, sloping and thinning to the south, and concentrated ice-contact features on the southern bedrock margin of the Paint Creek Valley. These deposits are uncommon.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Pleistocene, Illinoian glaciation)	Outwash (Higby Outwash) (Io)	**Io** resulted from glaciofluvial activity (streams associated with melting glaciers) adjacent to and beyond the Illinoian ice-margin position.The Higby Outwash occurs as large, flat-topped terraces, small terraces, pitted outwash plain, and terrace remnants in Ross County. Two distinct terrace levels are present, both of which grade southward away from the ice-margin position. Local relief between the two terrace levels decreases from about 12 m (40 ft) at Chillicothe to about 5 m (15 ft) at the Ross–Pike county line. The highest terrace is covered with patches of till. **Io** ranges in thickness from 13 to 44 m (42 to 144 ft).	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County *Slope processes*—this unit frequently exists as terraces perched on the sides of valleys. The relief inherent in such a setting renders it susceptible to slumping and sliding.	*Glacial features*—outwash, deposited by meltwater streams. *Geologic connections to park stories*—Hopewell Culture sites are located on outwash terraces, although no current park site is located on **Io**.	*Ice Age Glaciations*—The distribution of **Io** indicates the main Illinoian meltwater discharge path. Two levels of outwash may be attributable to deposition during two substages of Illinoian glaciation.
	Ground moraine (Rainsboro Till) (Ig)	Illinoian ground moraine covers a relatively planar, wedge-shaped area that trends northeast to southwest in central Ross County. In general, **Ig** is thin, patchy, and covered with loess to a depth of about 76 cm (30 in). Thickness ranges from 0 to 22 m (0 to 71 ft). Till of this age is deeply oxidized in a zone up to 4 m (14 ft) deep. Oxidized till is generally yellowish brown, whereas fresh exposures are dark gray. The clay-rich till is highly jointed and secondary deposits of clay within the joints are well developed. The thickest accumulations of this glacial drift are on north-facing slopes and in cols between bedrock knobs. The Rainsboro Till is oxidized to a depth of 5 m (15 ft) and is generally calcareous beneath a leached zone that reaches 216 cm (85 in) in depth. A thick wind-blown silt (loess) layer covers the till to an average depth of 75.7 cm (29.8 in).	*Disturbed lands and mineral resources*—sand and gravel may be targets of quarrying operations in Ross County *Slope processes*—may be prone to slumping.	*Glacial features*—till, deposited directly by glacier; moraines, mark extent of glacier. *Geologic connections to park stories*—as with many surficial units in the area, **Ig** may contain Hopewell or other archeological resources.	*Ice Age Glaciations*—Most of the moraine is restricted to the Appalachian Plateau upland areas, except for a small accumulation in the southeastern corner of Ross County. Thin Illinoian drift deposits suggest that the local ice stand duration was short.
QUATERNARY (Pleistocene, pre-Illinoian glaciation)	Lacustrine deposit (pl)	Locally referred to as the Minford Silt, this varved silt and clay deposit is at least 15 m (50 ft) thick. Individual varves (or annual layers) range in thickness from 1 mm to 1 cm (<0.1 to 0.4 in) with grain sizes grading from clay to very fine sand. The composition of the unit is slightly calcareous and has been oxidized to a depth of 5 m (17 ft). See also the descriptions of **Il** and **Wl**.	*Disturbed lands and mineral resources*—coarse sand, if present, may be target of quarrying operations in Ross County. *Slope processes*—may be prone to slumping if exposed on a slope.	*Geologic connections to park stories*—clay-rich lacustrine deposits may have provided mound construction materials. Different clay colors may have influenced placement. . Clay-rich lacustrine deposits were likely exploited as raw material for ceramic manufacture. Glacial features—lacustrine deposits from ice-dammed glacial lakes. *Paleontological resources*—lacustrine deposits often contain fossil pollen and other organic material. Lacustrine deposits may locally contain fossil mollusks.	*Ice Age Glaciations*—This pre-Illinoian unit may date to a previous glacial period (the Kansan) and formed in an extensive finger lake created by ice damming of the Teays-Stage drainage.
UNKNOWN (Silurian-Mississippian)	Nonsurficial deposit, most likely bedrock (br)	This unit is mapped where bedrock is exposed within the extent of the surficial map data, southeast of the High Bank Works site.	Refer to individual "Bedrock Units" described below.	Refer to individual "Bedrock Units" described below.	Refer to individual "Bedrock Units" described below.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
Bedrock Units					
MISSISSIPPIAN	Logan and Cuyahoga formations, undivided (Mlc)	The Logan Formation is characterized by brown or reddish-brown sandstone, siltstone, and shale with thick, planar, or lenticular bedding. The Cuyahoga Formation is comprised of gray or brown shale, minor sandstone, and siltstone that grades into massive sandstone layers with thick, planar, or lenticular bedding. The combined thickness of **Mlc** ranges from 76 to 320 m (250 to 1,050 ft). **Mlc** is mapped within the Spruce Hill site.	*Slope processes*—cliff-forming units, particularly the thick shales of the Cuyahoga Formation, are prone to rockfall and slumping.	*Paleontological resources*—units contain concretions that may be fossiliferous. Fossils from **Mlc** have not yet been documented within the park. The Cuyahoga Formation may contain mollusks (*Hippocardia herricki*, *Aphelakardia alternistriata*, and *Pseudomulceodens cancellatum*), ammonoids (*Muensteroceras oweni*, *Imitoceras sciotoensis*, and *Kazakhstania colubrella*), crinoids and trilobites (*Brachymetopus nodosus*). The Logan Formation may contain mollusks (*Pseudomulceodens cancellatum*), ammonoids (*Karagandoceras bradfordi*, *Kazakhstania colubrella*, *Imitoceras sciotoensis*, *Protocanites lyoni*, and *Gattendorfia andrewsi*), fish, and trace fossils. *Sedimentary bedrock features*—coarser grain sizes indicate higher-energy (shallower water) depositional environments.	*Longstanding Marine Deposition and the Rise of the Appalachians*—**Mlc** represents the youngest bedrock mapped in Ross County. It was deposited in the long-standing marine waters of the Appalachian Basin.
DEVONIAN and MISSISSIPPIAN	Sunbury Shale, Berea Sandstone, and Bedford Shale, undivided (DMu*)	The Sunbury Shale encompasses black, thin-bedded, carbonaceous (containing carbon) shale. The Berea Sandstone is characterized by brown or reddish-brown sandstone and minor shale, with bedding ranging from thick to thin and planar to lenticular. The Bedford Shale encompasses shale with interbedded sandstone, gray to brown in color with thin to medium, planar to lenticular bedding. The combined thickness of **DMu** ranges from 30 to 60 m (100 to 200 ft). **DMu** is mapped within the Spruce Hill site. *Recent stratigraphic definitions by the Ohio Division of Geological Survey (ODGS) have redivided "DMu" elsewhere in Ohio. Refer to Shrake et al. (2011).	*Slope processes*—cliff-forming units, particularly the Berea Sandstone, are prone to rockfall and sliding.	*Geologic connections to park stories*—mineral deposits in exposures of **DMu** and **Do** on Copperas Mountain may have led Hopewell peoples to construct mounds across Paint Creek at Seip Earthworks. Colors from minerals of **DMu** and **Do** likely inspired the names "Paint Creek" and "Copperas Mountain." The Berea Sandstone was used as building stone for the first Ohio statehouse in Chillicothe. Slabs or sandstone (perhaps the Berea) covered some Hopewell mounds and were occasionally used in tomb construction. *Paleontological resources*—fossils from **DMu** have not yet been documented within the park. Potential fossils from the sandstone units may include brachiopods (*Lingula melia* and *Orbiculoidea herzeri*), pelecypods, plants (*Callixylon* and *Annularia*), and/or spore casings as well as trace fossils such as burrows. The Sunbury Shale contains sponge and abundant conodont remains (*Synprioniodina alternate*, *Hindeodella subtilis*, *Polygnathus pennatulus*, *P. germanus*, *Panderodella truncate*, *Bryantodus inclinatus*, and *Lonchodina subtilis*). *Sedimentary bedrock features*—ripple marks are common in the Bedford Shale. Coarser grain sizes indicate higher-energy (shallower water) depositional environments.	*Longstanding Marine Deposition and the Rise of the Appalachians*—These units were deposited in the marine waters of the Appalachian Basin. Fluvial-deltaic environments alternated with stagnant sea environments during the deposition of sandstones and shales, respectively.

Colored rows indicate units mapped within Hopewell Culture National Historical Park. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
DEVONIAN	Ohio-Olentangy Shale, undivided (Do)	The Ohio Shale is a brownish-black to gray, thin-bedded carbonaceous shale with conspicuous concretions of carbonate (iron-rich siderite) in the lowermost 16 m (50 ft). The Olentangy Shale is a laminated or thin-bedded, gray, clay-rich shale with limestone nodules in the lower third of the unit. The combined thickness of **Do** is more than 75 m (250 ft). **Do** is mapped within Mound City Group, Hopeton Earthworks, Hopewell Mound Group, High Band Works and the lower flanks of Spruce Hill.	*Slope processes*—steep slopes of the Ohio Shale adjacent to Paint Creek at Spruce Hill and Seip Earthworks are prone to rockfall, sliding, and slumping. Concretions frequently weather out of the shales and fall to the river below.	*Geologic connections to park stories*— mineral deposits in exposures of **DMu** and **Do** on Copperas Mountain may have led Hopewell peoples to construct mounds across Paint Creek at Seip Earthworks. Colors from minerals of **DMu** and **Do** likely inspired the names "Paint Creek" and "Copperas Mountain." *Paleontological resources*—fossils from **Do** have not yet been documented within the park. Units contain abundant concretions that may be fossiliferous. Potential fossils include conodonts, radiolarians, arthropods, brachiopods (*Lingula*), bivalves, cephalopods, placoderm fish, shark, and occasional plant impressions. Carbonized plant remains include wood and ferns. Trace fossils include burrows and the annelid worm(?) *Sphenothallus*. The most common local fossil in the Ohio Shale is the macrospore *Protosalvinia huronensis*. *Sedimentary bedrock features*—small grain size and thin layers indicative of low-energy depositional environment. Ohio Shale has a characteristic petroliferous odor due to its carbon-rich composition. It is also a source of radon gas. *Concretions and nodules*—some concretions in this unit may reach the size of a small car. These unusual geological formations ("septaria") have attracted lay and scientific interest since at least the early 19th century. Pyrite nodules and disseminated pyrite are common.	*Longstanding Marine Deposition and the Rise of the Appalachians*—These units record organic-rich marine conditions during the Devonian Period. Limestones were deposited in warm, shallow-water conditions. Black, organic muds reflect a stagnant sea environment with limited circulation.
SILURIAN	Salina undifferentiated/ undifferentiated Salina dolomite (Ssu)	**Ssu** is predominantly gray and brown dolomite with thin bedding. Total unit thickness is approximately 72 to 102 m (235 to 335 ft). Sedimentary features within this unit include argillaceous (clay-rich) partings, brecciated intervals, algal laminations, and evaporite zones.	*Slope processes*—carbonate units may be prone to karst dissolution. Evaporites are similarly soluble and may cause local slumps or blockfalls.	*Geologic connections to park stories*—Silurian carbonate rocks may have provided temper material for Hopewell clay pot manufacture. *Paleontological resources*—algal laminations.	*Longstanding Marine Deposition and the Rise of the Appalachians*—Evaporites contained in the Silurian-age units reflect periods of aridity and shallow marine conditions with limited water input, which allowed the water to evaporate, leaving behind salts. Warm, shallow seas and coral reefs dominated the local marine basin at this time. Shallow seas also led to the deposition of the Silurian limestones and dolomites as part of a carbonate shelf and reef environment.
	Tymochtee Dolomite (St)	This unit consists of dolomite with thin carbonaceous shale layers. The unit appears olive gray to yellowish brown in outcrops and is 0 to 43 m (0 to 140 ft) thick with thin to massive bedding.	*Slope processes*—this carbonate-rich (dolomite) unit can be prone to karst dissolution.	*Geologic connections to park stories*—Silurian carbonate rocks may have provided temper material for Hopewell clay pot manufacture. *Paleontological resources*—stromatolites, ostracodes, gastropods, bivalves, nautiloids, and eurypterids occur in **St**.	
	Tymochtee Dolomite, Greenfield Dolomite, Peebles Dolomite, Lilley Formation, and Bisher Formation, undivided (St-b)	The Tymochtee Dolomite is a gray or bluish-gray, thin to medium, planar to lenticular bedded argillaceous (contains abundant clay) dolomite and minor shale unit. The Greenfield Dolomite contains thin to medium, planar-bedded, yellowish to gray dolomite lacking argillaceous layers. The Peebles Dolomite is characterized by thick to massive, planar to irregularly bedded gray dolomite. The Lilley Formation encompasses thin to thick, planar to irregularly bedded gray dolomite with minor limestone, chert, and shale. The Bisher Formation contains primarily argillaceous, thin to thick, planar to lenticular bedded yellowish or gray dolomite with minor shale The combined thickness of **St-b** ranges from 67 to 79 m (220 to 260 ft). **St-b** is mapped within the Seip Earthworks.	*Slope processes*—cliff-forming units may be prone to blockfall and landslides.	*Geologic connections to park stories*—Silurian carbonate rocks may have provided temper material for Hopewell clay pot manufacture. *Paleontological resources*—fossils from **St-b** have not yet been documented within the park. Bisher Formation includes chitinozoans, brachiopods, crinoids, and conodonts. Bioherms, which are mounds built by small organisms and composed of their remains, are common in Lilley Formation as well as conodonts. Stromatolites, ostracodes, gastropods, bivalves, nautiloids, and eurypterids occur in Tymochee Dolomite. Trace fossils include vertical tubes and rare, horizontal walking traces. Greenfield Dolomite contains conodonts in lower beds.	