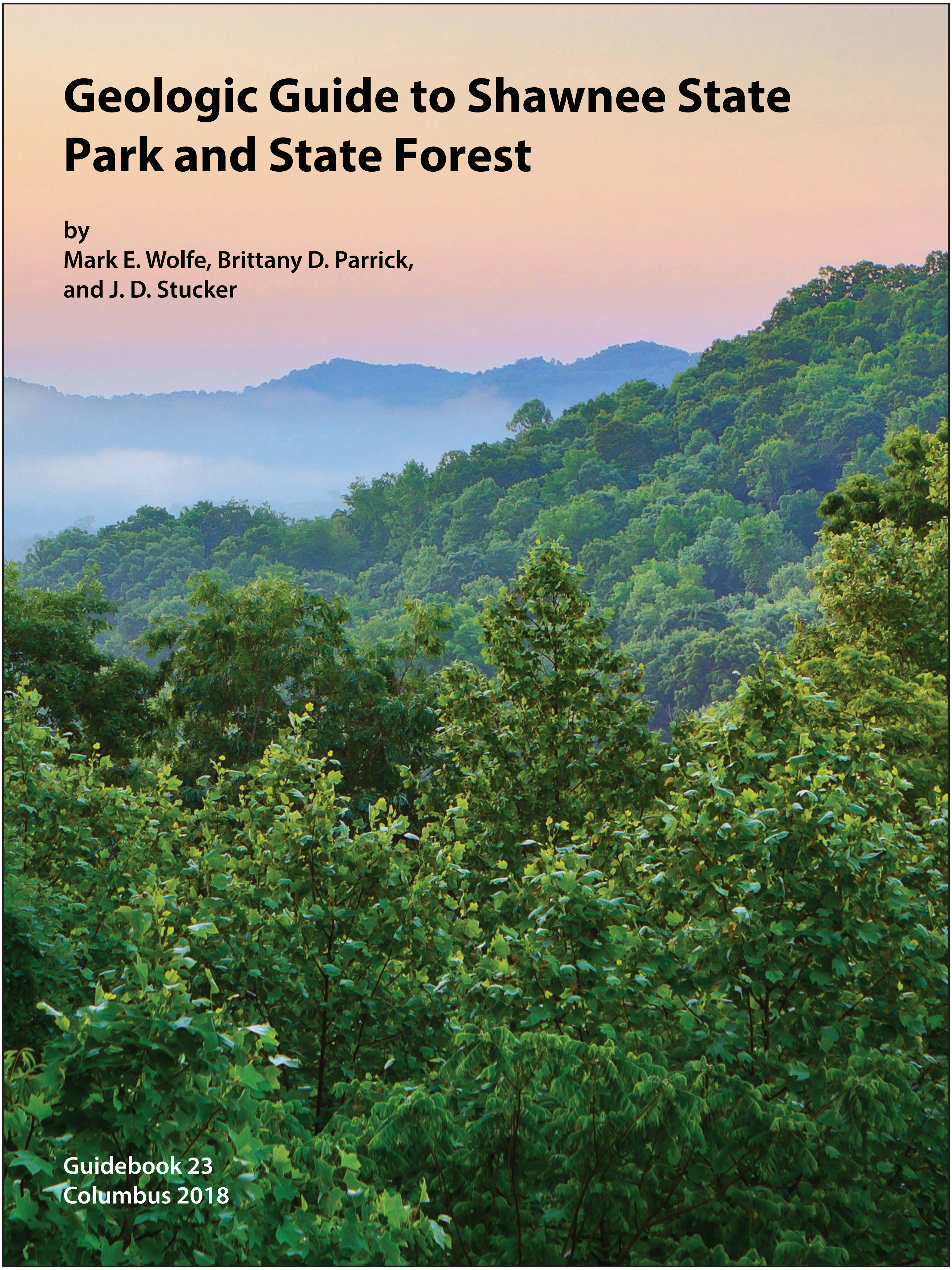
Geologic Guide to Shawnee State Park and State Forest

by
Mark E. Wolfe, Brittany D. Parrick,
and J. D. Stucker



Guidebook 23
Columbus 2018

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STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
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ABBREVIATIONS USED IN THIS GUIDEBOOK

Units of Measure

ft	foot/feet
gal	gallon(s)
in	inch(es)
mi	mile(s)
mi^2	square mile(s)
mm	millimeter(s)
psi	pounds per square inch

Other Abbreviations

CCC	Civilian Conservation Corps
lat	latitude
long	longitude
m.s.l.	mean sea level
mya	million years ago
ODNR	Ohio Department of Natural Resources
Rd.	road
Rte.	route

PREFACE

This guidebook is designed for a broad audience, from amateurs to professionals, and provides those visiting the Shawnee region with the information necessary to explore and appreciate the intricacies of the local and regional geology. The field guide portion of the book includes stops that examine the physical landscape, rock types, fossils, and cultural legacy of natural resources development. The large, folded map provided with the guidebook is designed to augment information provided in the text, but it also can serve as a stand-alone feature for use while exploring. To encourage further exploration of the regional geology, brief descriptions of areas of interest near Shawnee are also provided. Finally, many new terms appear in **bold print** when they are first introduced in the text. These terms are explained in an easy-to-use glossary at the end of this guidebook.

When enjoying any field trip in Ohio, please make safety a primary concern and abide by the following guidelines:

- Always adhere to federal, local, and state traffic laws.
- Many of the stops can be accessed along public rights-of-way, where wearing an orange safety vest is recommended.
- Wear hardhats and shoes or boots with good tread and plenty of ankle support, as some sites might present wet, muddy, and uneven terrain with loose rocks and sediment.
- Never climb on outcrops.
- Wear clothing appropriate to the environment and changing weather conditions.
- For sites on private property, always obtain permission from property owners before entering and comply with any rules they have for visitors.
- Collecting of rocks, minerals, or fossils in State Parks and State Forests is against the law without a permit. All collecting should be done only with the permission of the landowner (in this case, State of Ohio, Department of Natural Resources) and is not encouraged unless as part of a scientific investigation.

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INTRODUCTION

Ohio is a land of contrasts—urban, suburban, farm, forest, and mine—and the foundation for all is the underlying geology. The great manufacturing and industrial cities of Cleveland and Cincinnati exist because of their locations on two major water transportation features, Lake Erie and the Ohio River, both created by continental glaciation that occurred thousands of years ago. These glacial events also created the rich farmland that supports agriculture, Ohio's largest industry. The hills of southern Ohio lie outside of direct glacial influence, but the current topography was affected by huge amounts of meltwater released as the glaciers receded. Many communities of southern Ohio are heavily dependent on the extraction of natural resources such as coal and wood to support local industries. These natural resources exist because of the area's geology. Today, an important component of the local economies of southern Ohio is the recreational aspect of the beautiful hills and valleys. Hiking, hunting, fishing, bird watching, camping, and boating are some of the quality-of-life activities that enhance the area.

The dramatic landforms and resulting biodiversity of southern Ohio is best represented by the area encompassing Shawnee State Park and State Forest. The nearly 65,000 acres of state-owned land, located primarily in western Scioto County, stretches into adjoining eastern Adams County (fig. 1). The rugged topography has been shaped

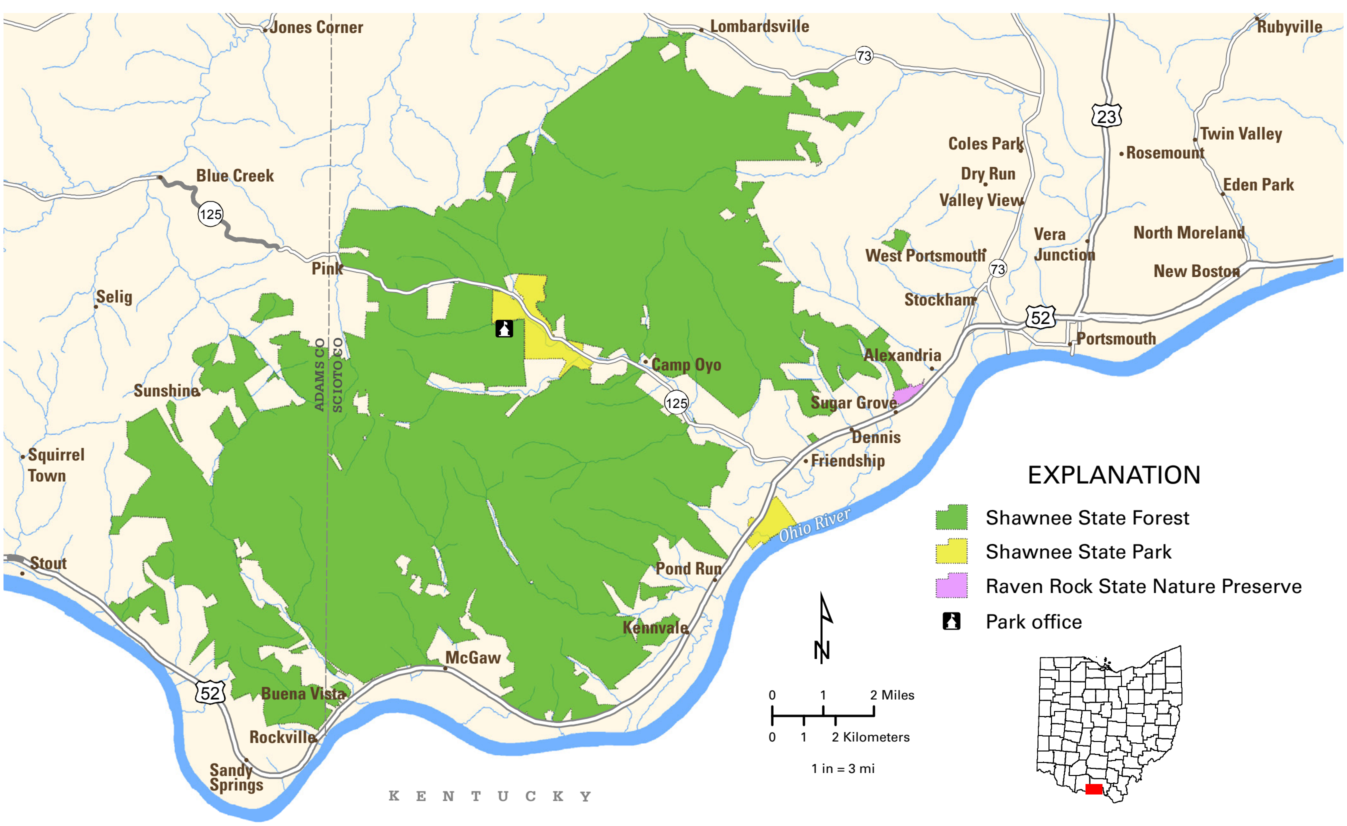

FIGURE 1.—General location map showing Shawnee State Park and State Forest and surrounding area in southern Ohio.

by geologic processes that began millions of years in the past and continue today. Local topographic relief exceeds 500 feet (ft) in many places. The Ohio River valley defines the southern boundary of the Shawnee region and influences erosion along the steep ravines that flow toward “The Big River,” the phrase used by Native Americans to describe the waterway to early European settlers. The Shawnee tribe, for which the forest and park are named, used descriptive language translated as “eagle river” or “moving fast” to distinguish this important early transportation corridor.

Beyond the eastern boundary of the Shawnee region is another large stream, the Scioto River, which originates approximately 150 miles (mi) to the north in Ohio. The Scioto River affects local topography because of the down-cutting of its tributaries and changing course through meanders. The wide valley in which the Scioto River flows was occupied by a larger stream thousands of years ago. This ancestral river flowed north and was a major tributary to the Teays River. The Teays River originated in North Carolina, flowing northward through Virginia and West Virginia into central Ohio, then continuing westward into Indiana (Hansen, 1987). The relict valley of the Teays River can be followed north from Wheelersburg. The existing Ohio and Scioto River valleys, west and north of Portsmouth, respectively, contained a major north-flowing river that joined the Teays near Piketon.

To the north of the Shawnee area, a meandering stream named Scioto Brush Creek crosses varying geology that includes, from west to east, dolomite, shale, sandstone, and siltstone. The various rock types affect the surrounding landforms and vegetation along the creek. Shales erode more quickly, forming the numerous “hollows,” while dolomites and sandstones are more resistant and form the ridges. The 13,500-acre Brush Creek State Forest is located north of Shawnee State Forest.

The topography west of the Shawnee area is influenced by a change in geology from one dominated by sandstone, siltstone, and shale in the east to mostly dolomite and shale in the west. Though the differential erosion between the shale and dolomite continues to create a rugged topography in the west with local relief exceeding 400 ft, elevation changes are generally less pronounced and vegetation that prefers carbonate-based soils becomes more abundant. The south-flowing Ohio Brush Creek is located west of the Shawnee region, as is the 17,000-acre Edge of Appalachia Preserve owned by the Ohio Chapter of the Nature Conversancy and managed by the Cincinnati Museum Center. Edge of Appalachia contains eleven separate preserves, four of which are National Natural Landmarks, and is considered of global significance. State and private conservation areas in this part of southern Ohio constitute nearly 100,000 acres of critical habitat for plants and animals often not found elsewhere in Ohio or the United States.

HISTORY OF SHAWNEE STATE PARK AND STATE FOREST

The original land acquisitions that later became Shawnee State Forest began in 1922 when the Theodore Roosevelt Game Preserve was dedicated in Scioto County, Ohio (fig. 2). President Roosevelt was a long-time champion of conservation, having set aside more than 230 million acres of Federal land during the early 1900s and establishing the U.S. Forest Service. Funds for the preserve land purchase were raised through hunting license fees and by the state agricultural extension division for the purpose of wildlife conservation and reforestation. The State of Ohio purchased the mostly cleared and fire-ravaged property for the bargain price of $5 per acre. This visionary State acquisition was one of the first and largest of its kind in the United States, leading to re-establishment of wildlife, such as turkey, deer, and pheasant, which had been virtually eliminated from Ohio. Researchers into forest ecology, including leading experts such as Emma Lucy Braun of Cincinnati, were able to study the rejuvenated forest ecology and compare it to old-growth forests in the southern Appalachian Mountains. Braun published her ground-breaking book, *Deciduous Forests of Eastern North America*, in 1950 after decades of field research that included southern Ohio and the Shawnee area.

During the Depression years of the 1930s, seven Civilian Conservation Corps (CCC) camps were located in the Shawnee State Forest. Four of the seven CCC camps were extremely rare, segregated groups comprised entirely of African-American enrollees, including one exclusively of World War I veterans—Company 1545 (Feight, 2014). The CCC built roads into inaccessible areas of the forest and constructed five small lakes for water-supply as well as for fishing and other recreation (fig. 3). Stone for dams, buildings, and roads was supplied by quarries located within the forest (fig. 4). Building stone had been produced commercially for more than a century at nearby Buena Vista, Ohio, as well as northeast at McDermott, so stone masons and individuals with expertise in quarry methods were readily available (fig. 5).

In 1932, the core of Ohio’s present deer herd was stocked at the Roosevelt Game Preserve (Reynolds, 2004). In 1934, the state set aside 400 acres of the Roosevelt Preserve for the creation of a state park. The state park was originally called Roosevelt State Park; the name was later changed to Portsmouth State Park. After the creation of the Ohio Department of Natural Resources in 1947, the area became known as Shawnee State Park. Today, the 1,165-acre park includes a full-service lodge, cabins, camping, swimming, a marina on the Ohio River, and an 18-hole golf course. The surrounding 63,000-acre Shawnee State Forest includes miles of hiking and horseback riding trails, access for hunting, and small lakes for fishing. The forest is also managed for multiple

FIGURE 2.—Workers and family at Shawnee State Forest, Ohio, *circa* 1922. Note the bag of Alpha Portland Cement on the back of the truck. The cement was produced from the underground limestone mine and cement plant at Ironton, Ohio. The flatbed truck has a "State Car" license plate. Photo courtesy of Jenny Richards, Ohio State Parks & Watercraft.

FIGURE 3.—Civilian Conservation Corps crew constructing Churn Creek Lake dam, *circa* 1930s, Shawnee State Forest, Ohio. Photo from the Ohio Agricultural Experiment Station, Department of Forestry collection at The Ohio State University.

FIGURE 4.—Civilian Conservation Corps crew drilling and blasting large slabs of sandstone to be used for construction of roads, bridges, and other structures in Shawnee State Forest, Ohio, *circa* 1930s. Photo from the Ohio Agricultural Experiment Station, Department of Forestry collection at Ohio State University.

FIGURE 5.—An example of the superb stonework completed by the Civilian Conservation Corps (CCC) in the Shawnee State Forest, Ohio, *circa* 1938. This bridge crossed Turkey Creek just below Roosevelt Lake Dam. The piers and abutments were removed and replaced with a modern bridge in 2016. An original pier and an abutment were retained and used to create a memorial, placed at the shelter house on Mackletree Road, to the African American CCC workers who constructed the bridge (Charles Egbert, ODNR Division of Forestry, written comm., 2018). Photo courtesy of ODNR Division of Forestry.

uses, including sustainable timber production and wildlife habitat preservation. The 8,000-acre Shawnee Wilderness Area was designated by the state in 1972, three years prior to the Federal Eastern Wilderness Act. The 8,000-acre back country management area was created in 1999 as a buffer to the wilderness area and to provide opportunities for management of forest wildlife, including rare and endangered species. Shawnee contains many miles of forest roads for scenic drives and provides access to explore the local geology over the expansive area.

GEOLOGY OF SHAWNEE STATE PARK AND STATE FOREST

Physiography

The area that encompasses Shawnee is located primarily in the Allegheny Plateaus section of the Appalachian Plateaus Province and is locally named the Shawnee-Mississippian Plateau (fig. 6; Ohio Division of Geological Survey, 1998). It is considered the most rugged area in Ohio and characterized by high-relief, highly dissected topography. The maximum glacial advance is located to the north with remnants of **lacustrine** clay-filled valleys on the eastern margin. The Allegheny **Escarpment** separates Shawnee from the Outer Bluegrass Region of the Interior Low Plateaus to the west. The Outer Bluegrass Region is characterized by moderate relief on a dissected carbonate plateau. Approaching the Shawnee area from the west, the low-relief, glacially derived till plains contrast dramatically with the unglaciated Outer Bluegrass Region. Traveling farther east, the Shawnee region is further defined by the Allegheny Escarpment and Shawnee-Mississippian Plateau. From the north and east, the wide Scioto River valley contrasts with the hills of the Allegheny Plateau to the west, providing a scenic approach to the Shawnee region.

Paleogene and Neogene Periods, the Teays River, and the Effects of Glaciation

Paleogene- and Neogene-age (66–2.6 million years ago [m.y.a.]) geologic deposits do not exist in Ohio, having been removed by erosion, but the widespread effects of a large river system formed during that time are readily apparent from Portsmouth to Chillicothe. This ancient river was named the Teays River after a small village in West Virginia. The headwaters are believed to have formed in western North

FIGURE 6.—Generalized physiographic regions of Ohio (modified from Ohio Division of Geological Survey, 1998).

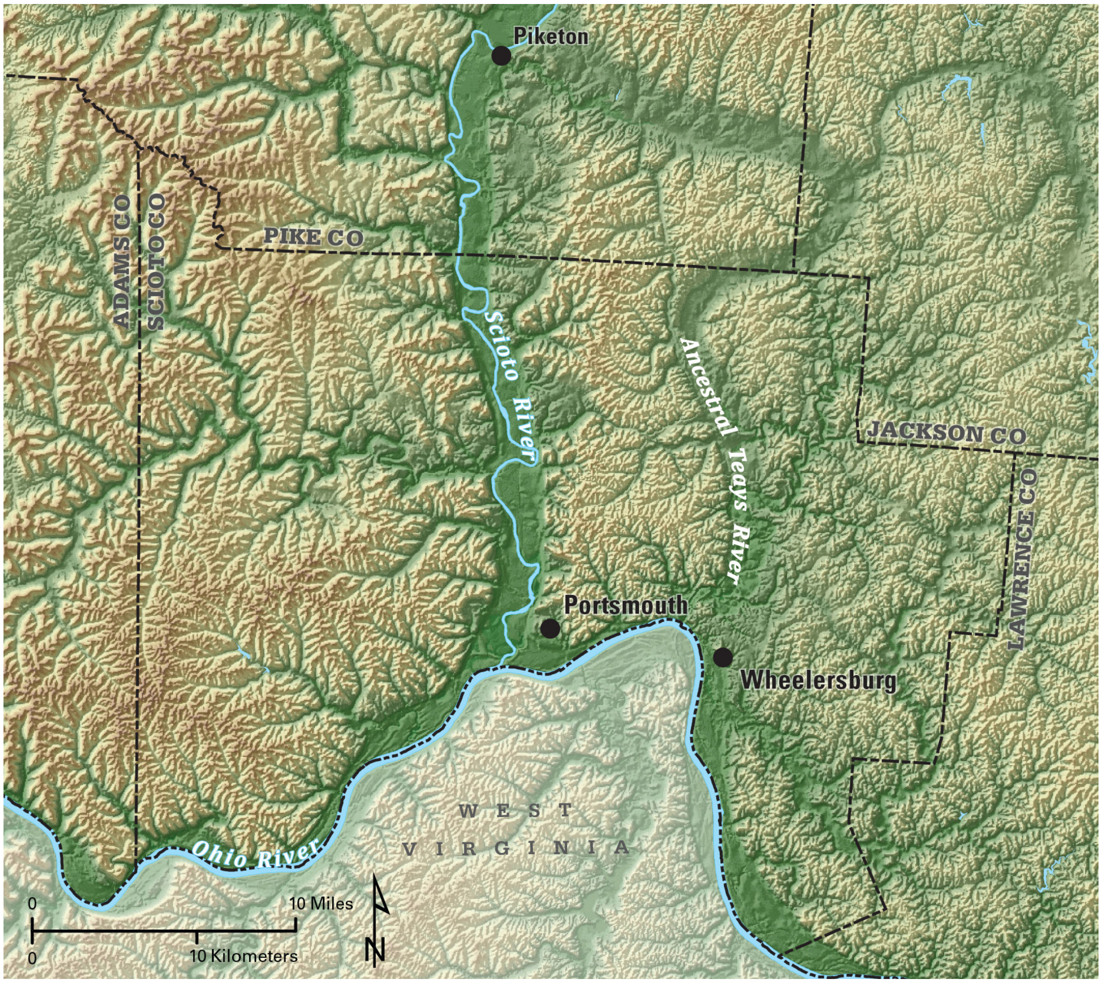

FIGURE 7.—A portion of the *Shaded Elevation Map of Ohio* showing abandoned segments of the Teays River in southern Ohio and adjacent West Virginia. Modified from Powers and others (2002).

Carolina and the course of the stream across Virginia and West Virginia is marked by the modern New River (actually a very old stream) and the Kanawha River (Hansen, 1987). The *Shaded Elevation Map of Ohio* (Powers and others, 2002) show the relict Teays River valley as it diverges from the Kanawha River valley at St. Albans, West Virginia, and flows toward Proctorville, Ohio, where it joins an old channel of the Ohio River. At Wheelersburg, the Teays diverted from the modern Ohio River channel and flowed northward in a wide valley to south of Piketon, Ohio, where it was joined by the large tributary called the Portsmouth River that flowed northward in the modern Scioto River valley (fig. 7). An additional large tributary named the Marietta River flowed westward across Gallia and Jackson Counties to join the Teays near Piketon (fig. 8). This enormous drainage system would rival the modern Mississippi River, as evidenced by the several-miles wide, modern active and abandoned river valleys in southern Ohio.

The geologic history of the Teays River drainage system has been subject to debate among geologists for more than 100 years. Many details concerning the pre-glacial drainage of southern Ohio still is not well understood, but the series of maps published by Stout and others (1943) form the basis by which modern interpretations can be made. The maps depict a fascinating history of a series of glacial advances during the Pleistocene Epoch (2.6 m.y.a.–11,700 years ago) into northern and central Ohio that radically changed the courses of rivers and streams throughout the state. As continental glaciation advanced from the north during the Pleistocene Epoch, the Teays River became blocked by ice, hundreds to thousands of feet thick, and the stream flow was redirected southward into the current Scioto River channel. A huge **pluvial** lake was formed that covered much of southern Ohio and adjacent northeastern Kentucky and southwestern West Virginia (fig. 8). This enormous lake was named Lake Tight to honor the early geologist that first recognized its existence (Coffey, 1961). Within this quiet lake environment, extensive fine-grained sediments were deposited named the Minford clay (OGS-GSK, 1968). The Teays River drainage was diverted initially into the

FIGURE 8.—Regional map depicting the extent of glaciation, pre-glacial drainages including the Teays River, and the location of the ancestral glacial Lake Tight. Modified from Hansen (1987)

ancestral Ohio River channel that flowed northward toward Pittsburgh. As multiple glaciations occurred, the Teays River would eventually break through a drainage divide west of Portsmouth, Ohio, to form the modern southwest-flowing Ohio River (fig. 8, Coffey, 1961).

The *Shaded Bedrock-topography Map of Ohio* depicts the configuration and elevation of the bedrock surface and is an essential tool for understanding the changes to the Teays River and its tributaries in southern Ohio during the Pleistocene Epoch (Brockman and others, 2003). Careful study of the map reveals valleys that were scoured by the erosional forces of the Teays River and its tributaries and later buried by glacially derived deposits, particularly north of Chillicothe closer to the advancing ice. The portion of the Teays River north of Wheelersburg was abandoned relatively early during the Pleistocene Epoch, as its scoured bedrock valley is actually higher than the bedrock valley of the current Scioto River. The retreat of the glacier created tremendous volumes of meltwater that would both erode deep channels and deposit large amounts of sand and gravel, termed *outwash*, onto higher-level terraces. Various types of glacial and more recent deposits, such as **alluvium**, outwash, and lake or lacustrine silts and clays, are depicted on the *Quaternary Geology of Ohio* map (Pavey and others, 1999a).

Bedrock Geology

A casual look at the bedrock geology of the Shawnee area would lead to the erroneous conclusion that **stratigraphic** relationships are easily understood, but as with much of Ohio geology, the challenge is in the details. Rocks found at the higher elevations in the eastern and central portion of the Shawnee area are primarily **interbedded** sandstones, siltstones, and shales of the Mississippian (360–325 m.y.a.) Logan Formation (fig. 9). The Logan Formation is more than 180 ft thick and can be further subdivided (from top to bottom) into two **members**: the Vinton Member and the Byer Member (Hyde, 1953). The coarse-grained Allensville and Berne Members of the

Logan Formation found in south-central Ohio cannot be identified in the Shawnee region. The Byer Member is dominated by medium- to thick-bedded, very fine-grained sandstones and siltstones with occasional very thick-bedded sandstones. The Vinton Member is finer grained and thinner bedded than the Byer Member, with more distinctive **fossiliferous** zones. The lack of continuous outcrops, poor fossil preservation, and heavy vegetation make stratigraphic correlations difficult.

Sandstones, siltstones, shales, and clays of the Mississippian Cuyahoga Formation underlie the Logan Formation (fig. 9). The Cuyahoga Formation is approximately 140 ft thick in the Shawnee region. The top 100 ft of the Cuyahoga Formation contains red and blue shales and claystones of the Portsmouth Shale Member. The Portsmouth Member and other local clays or shales once supported a vibrant ceramic industry, including large paving brick manufacturers in the Portsmouth, Ohio, area during the early twentieth century. The Portsmouth Member is in the general stratigraphic position of the coarse-grained to **conglomeratic** Black Hand Member of the Cuyahoga Formation found to the northeast. Underlying the Portsmouth Member is the thick- to very thick-bedded, very fine-grained sandstone and siltstone of the Buena Vista Sandstone Member. The Buena Vista Member is variable in thickness but is generally less than 20 ft thick. The trace fossil, *Zoophycos*, is a prominent and dependable diagnostic feature of the Buena Vista Member in the Shawnee area (fig. 10; Hannibal, 1995). The Buena Vista Member was a historically important source of building stone quarried in southern Ohio, and it was shipped extensively on the Ohio River. The Waller Brothers Stone Company continues to quarry the Buena Vista Member northeast of Shawnee near the town of McDermott, producing laboratory table tops as well as specialty cut-stone products. The gray Henley Shale Member underlies the Buena Vista Member and is transitional to the underlying Sunbury Shale (Hyde, 1953).

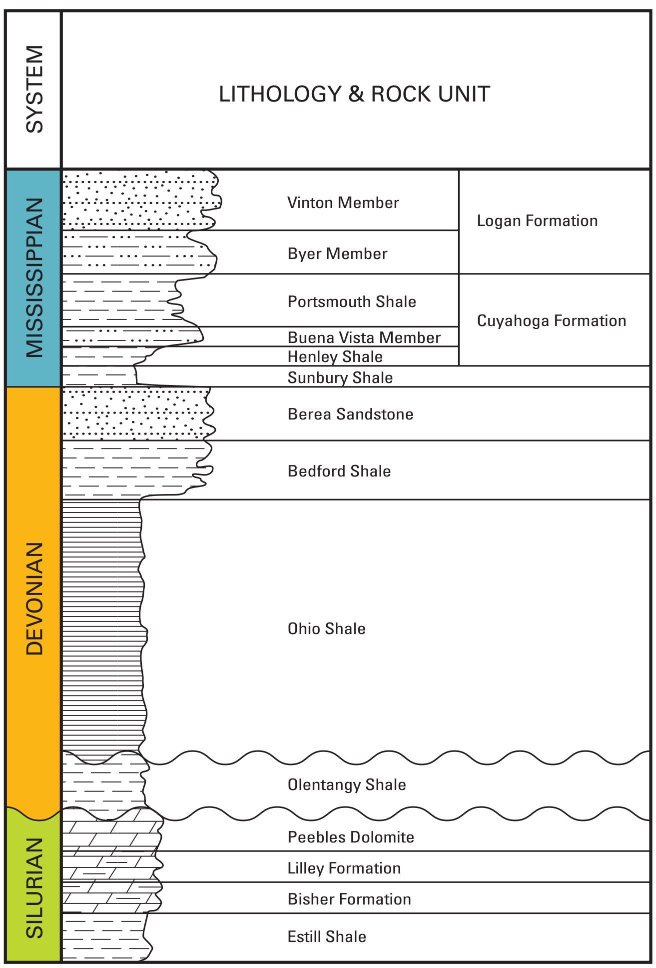

FIGURE 9.—Generalized stratigraphic column of the Shawnee State Park and State Forest region, Scioto and Adams Counties, Ohio.

The Mississippian Sunbury Shale is black, **organic-rich**, highly **fissile** shale often with a **petroliferous** odor (Hansen, 2001). Deposited in a nearshore lagoonal environment, the Sunbury Shale is the uppermost of three organic-rich shales that were deposited during the Late Devonian and Early Mississippian Periods (383–360 m.y.a.) in Ohio (fig. 9). The Sunbury Shale is approximately 20 ft thick and is found on the middle to lower slopes and drainages in the central portion of the Shawnee area.

Underlying the Sunbury Shale is the Berea Sandstone (fig. 9). The Berea Sandstone contains fine- to medium-grained, thick-bedded sandstone and minor interbedded shale and siltstone. Small crystals of pyrite, which oxidizes on exposure to the atmosphere, may also be found (Hyde, 1953). The Berea Sandstone may be up to 50 ft thick. Ripple marks occur throughout, and **soft-sediment deformation** is common at the base of the Berea Sandstone (Schumacher and others, 2013). The Berea Sandstone is considered Late Devonian in age in northern Ohio, but may be Early Mississippian in southern Ohio (Slucher and others, 2006).

The Devonian (419–360 m.y.a.) Bedford Shale (fig. 9) is actually a series of interbedded sandstones and shales that gradate into the overlying Berea. A distinctive feature of the Bedford Shale is the existence of red or green shales, particularly toward the base of the unit. When these shales are missing, the contact of the Berea Sandstone and Bedford Shale can be difficult to identify in the field, and the two units are sometimes mapped as a single unit (Slucher and others, 2006). The Bedford Shale is approximately 80 ft thick in the Shawnee area. The Berea Sandstone and Bedford Shale are located in the lower drainages in the eastern and central portions of the Shawnee region, becoming part of the ridge-forming Allegheny Escarpment to the west.

The Devonian Ohio Shale is an organic-rich, brown to black, fissile shale that underlies the Bedford Shale (fig. 9). The Ohio Shale is up to 300 ft thick and may include carbonate concretions that contain occasional plant or animal fossils (Hansen, 1999; Schumacher and

FIGURE 10. —The trace fossil (ichnofossil) *Zoophycos*, resembling a rooster tail, in a siltstone slab near the entrance to Shawnee State Park lodge, Scioto County, Ohio.

others, 2013). The Ohio Shale is found near the Ohio River and lowermost drainages in the central Shawnee area, becoming erodible slopes to the west. The base of the Devonian shales in southern Ohio may or may not contain the Olentangy Shale. Where the Olentangy Shale does outcrop in southeastern Adams County and southwestern Scioto County, it consists of alternating black, **carbonaceous** shales and dark-blue to blue-green claystone that may contain carbonate nodules, particularly toward the base of the unit (Lamborn, 1929). A major **unconformity**, possibly representing 65 million years of erosion or nondeposition, is found at the base of the Devonian in southern Ohio (Brett and others, 2012).

The Silurian (443–419 m.y.a.) Peebles Dolomite underlies the Ohio Shale in Adams and Scioto Counties (fig. 9). The Peebles Dolomite is a thick- to massive-bedded, gray to blue-gray dolomite that is approximately 40 ft thick and characterized by its abundant porosity and large **vugs** that weather to a pitted and corroded surface. Skeletal fragments of a diverse marine fauna are common, including the diagnostic brachiopod *Pentamerus* in the lower part of the unit (Schumacher and others, 2013). The Peebles Dolomite is laterally equivalent to the Cedarville Dolomite of western Ohio. The Peebles Dolomite and underlying Lilley Formation form cliffs in the southwestern portion of Shawnee State Forest.

The Silurian Lilley Formation underlies the Peebles Dolomite with a **gradational contact** (fig. 9). The Lilley Formation consists of gray to blue-gray, silty to shaley, fine-grained fossiliferous dolomite and medium- to coarse-grained fossiliferous dolomite with planar to irregular bedding. Occasional beds of dolomitic shale and minor beds of shale and limestone also may be found (Schumacher and others, 2013). The Lilley Formation is approximately 45 ft thick. Marine fauna are common with crinoids dominating. Coral and stromatoporoid **bioherms** can be found locally (Flanigan, 1986).

Underlying the Lilley Formation is the Silurian Bisher Formation (fig. 9). The lithology is similar to the Lilley Formation, being characterized by silty to shaley, fine- to coarse-grained dolomite with minor dolomitic shale. Unlike the Lilley Formation, the Bisher Formation contains minor chert nodules and geodes, as well as abundant cross bedding and cross lamination. It has a somewhat restricted fossil assemblage with brachiopods and crinoids dominating. The basal Bisher Formation contains a highly fossiliferous zone dominated by the brachiopod *Cryptothyrella*, which occurs throughout southern Ohio and northeastern Kentucky. The Bisher Formation is approximately 20 ft thick and overlies the Estill Shale with a sharp, undulating contact (Schumacher and others, 2013).

The Silurian Estill Shale (fig. 9) is Early (Wenlock, 433–427 m.y.a.) Silurian in age and exposed in the Ohio River valley and lowermost drainages in southeastern Adams County. It is predominately a medium-bedded, green-gray to red-gray dolomitic shale interbedded with burrowed, **calcareous** dolomite. Abundant **glauconite** occurs in the basal 1–2 ft of the unit. The Estill Shale is not resistant to weathering, rapidly forming **colluvium**. It is sparsely fossiliferous but contains trace fossils and pyrite-filled burrows (Schumacher and others, 2013). The Estill Shale is approximately 60 ft thick.

A small area of the Silurian Drowning Creek Formation underlies the Estill Shale along Sulphur Creek north of U.S. Rte. 52, just south of the Shawnee State Forest boundary (Slucher and others, 2006). The Drowning Creek Formation is characterized by interbedded fossiliferous limestone, dolomitic limestone, chert, and shale (Schumacher and others, 2013). The term Drowning Creek was introduced to better define the Lower Silurian stratigraphy in eastern Kentucky and was mapped into southern Ohio, replacing the Brassfield Formation and associated units (McDowell, 1983; Swinford, 1985). Because of the limited exposures in the Shawnee area—all on private property—a more detailed field description of the Drowning Creek Formation will not be included in this publication.

Recent research in the Shawnee area, conducted by Ohio Geological Survey geologists, has reevaluated the mapping and naming of geologic formations in the region. The Mississippian-age strata in the Portsmouth area, historically referred to as the Logan and Cuyahoga Formations, resemble the Borden Formation in nearby north-central Kentucky more closely than the Logan and Cuyahoga Formations in central and northeastern Ohio (Blakeman, 2017). These units have been renamed on recent detailed bedrock maps to Borden Formation member names to better reflect these geological differences (Fugitt and Blakeman, 2016). The Borden Formation's Farmers Member, Nancy Member, and Cowbell Member correlate to the Buena Vista Member of the Cuyahoga Formation, Portsmouth Member of the Cuyahoga Formation, and Logan Formation, respectively. However, more traditional terms such as the Logan Formation or the Buena Vista Member of the Cuyahoga Formation still hold regional importance.

Historical Geology

The geology observed in the Shawnee region was created by millions of years of plate tectonics that resulted in multiple phases of mountain-building (known as *orogenies*) of the ancestral Appalachian Mountains, long-periods of erosion, and sea-level fluctuations onto the Cincinnati Arch; these processes led to shallow marine deposition over large areas in Ohio. Major mountain-building episodes during the Silurian, Devonian, and Mississippian Periods created environments in which organic-rich shales, siltstones, and fine-grained sandstones were deposited. A brief description of the historical geology of the Shawnee region follows, but many online resources provide for more detailed information.

The formation of the modern Appalachian Mountains, stretching 1,800 mi from northeastern Canada to northern Alabama, had a major influence on the geology of the Shawnee region. The first major mountain-building event in eastern North America is named the Taconic Orogeny and began during the Ordovician Period (488–443 m.y.a.). A **subduction zone** that developed along the northern margin of the North American plate led to major uplift, **thrust faults**, and **metamorphism** in the Appalachians. During Early Silurian time, the Cincinnati Arch was a topographically positive structural feature surrounded by shallow seas on the west, north, and east. It was into these seas east of the Cincinnati Arch that the Estill Shale, Lilley and Bisher Formations, and Peebles Dolomite were deposited. As the Taconic Orogeny continued into the Late Silurian and Early Devonian Periods, a major erosional unconformity developed in the Shawnee region. Nearly 65 million years of erosion is reflected in the absence of Late Silurian through Middle Devonian geologic units found elsewhere in Ohio.

A second major mountain-building event, the Acadian Orogeny, occurred during the Middle to Late Devonian. The ancestral Appalachian Mountains ("Acadian Mountains") were again uplifted. The Ohio and Olentangy Shales were deposited in a marine basin to the northwest of the Acadian Mountains. As the Appalachian highlands eroded during the Late Devonian, sea levels dropped and the Cincinnati Arch emerged. The Bedford sandstone and shale sequence and Berea Sandstone were deposited in this nearshore, shallowing environment. As erosion continued and sea-levels dropped well into the Mississippian Period, the Sunbury Shale was deposited in broad coastal lagoons receiving plant **detritus** from local sources.

A long period of erosion continued during the Mississippian Period and coincided with uplift of the Canadian Shield to the north and subsidence of the Appalachian Basin to the south. A slow lowering of sea level resulted in the deposition of the very fine-grained sands, silts, and shales of the Cuyahoga and Logan Formations. Though the nearshore and shallow marine conditions were ideal for crinoids, brachiopods, corals, gastropods, and trilobites, the environment was subject to major storms and other high-energy events that make fossil preservation poor.

The Appalachian Mountains were uplifted and eroded at least two additional times, but in the Shawnee area, only erosion has occurred since the Mississippian. Thus the Appalachian Mountains record nearly 500 million years of uplift, deformation, and erosion. The Appalachian Plateau borders this geologically complex area and is underlain by rocks that have been more gently deformed; large-scale folding, faulting, and fracturing is not common but can be found locally at the surface and becomes more common with depth.

Economic Geology

The Ohio Geological Survey was commissioned by the Ohio Legislature to develop a geologic framework for the state, primarily to help define the extents and characteristics of the economic resources within its boundaries. The first geologic fieldwork took place in 1837–1838 and was done on horseback. Dr. John Locke was an assistant with the first Ohio Geological Survey and one of the first professional geologists to explore the Shawnee region. Locke had graduated from Yale Medical School in 1819, opened a School for Young Ladies in Cincinnati in 1823, and in 1828 helped establish the Ohio Mechanics Institute. In 1836, Locke became professor of chemistry at the Medical College of Ohio and was known as an expert in magnetism, improving many instruments, including the spirit level, which he used extensively while mapping in southern Ohio.

During the 1830s, eastern Adams County and Western Scioto County were sparsely populated, an untamed wilderness abounding in geological wonders. Locke described inhabitants and situations that were not part of his more "civilized" background. One such incident occurred while surveying Scioto Brush Creek, just east of the Scioto County line. The mapping party returned after completing some level work to find their horse had been untied and a hog with oats tied to it was attempting to lure the equine down the road:

> *It appeared as if the plan had been laid by a "native" to have the hog with its oats entice the horse, and the horse pursue and impel the hog. This exhibited a grade of wit certainly not very high in the scale, but yet quite as high as a large proportion of that which seems to be very self-satisfying to its author. The horse being too well disciplined in its duty of eighth geological assistant to be guilty of any such insubordination, kept his ground. (Locke, 1838)*

Locke goes on to describe the subsequent encounter with the man that had provided the oats to the hog and the resulting events that led to the wagon overturning. Locke is slightly injured while trying to keep both his accompanying son and precious level from harm. After later arriving at Rockville, Ohio, he describes the entire area as "terra incognito," a peculiar region (Locke, 1838).

Building stones

Professor Locke's visit to Rockville documents the bustling quarry activity in the region. A detailed description of the nearby Loughry quarry that includes the "City Ledge" (Buena Vista Member of the Cuyahoga Formation) is included in the 1838 report. The approximately 4-ft thick bed of fine-grained sandstone was being quarried and shipped in large quantities to Cincinnati. Additional portions of the geologic section being used as building stone include the "White Ledges" (Berea Sandstone) and the "Beautiful Quarry" (Byer Member of the Logan Formation). Even though several other quarries were active in the area, Professor Locke remarks that the quarry at Rockville had the advantage of being on the high bluff overlooking the Ohio River, with easy access to that vital transportation corridor.

The first stone quarry in the Shawnee area was established by Joseph Moore in 1814 and was located between Rockville and Buena Vista. Between 1814 and 1830, Moore rafted large quantities of stone taken from the hillside to Cincinnati, where it was used for building purposes (Bownocker, 1915). Moore was succeeded in the stone business by John Loughry, who located at Rockville and brought with him 16 yoke of oxen and 70 men to supply stone for the canal locks and construction at bustling Cincinnati. The Buena Vista Member has the distinction of being the only building stone used for lock construction on both the Ohio & Erie and Miami & Erie Canals (Hannibal, 1998). Loughry first constructed chutes on the hillside in which stone could slide downhill, later building good wagon roads, and then finally inclined railroads with small locomotives to deliver the stone to sawmills initially constructed in 1847 at Buena Vista (Bownocker, 1915).

The quarry business expanded in southwestern Scioto County and southeastern Adams County into the 1870s. Additional successful quarry operators included the Caden Brothers, John M. Mueller, J. W. Adams, J. W. Flagg, and the Buena Vista Freestone Company. Quarries to the east supplied stone to two sawmills in Portsmouth (Andrews, 1891). A number of important existing structures in downtown Cincinnati were constructed with the Buena Vista Member, including, but not limited to, the Roebling Suspension Bridge, L & N Bridge, columns on the front of the St. Peters in Chains Cathedral, and trim on the Plum Street Temple and the Covenant-First Presbyterian Church (Hannibal and Davis, 1992). The Buena Vista Member also was used for building construction, particularly for trim, in New York; Chicago; Louisville; Pittsburgh; Detroit; and Washington, D.C. In addition, it was used to construct railroad bridges at Kenova and Point Pleasant, West Virginia, and waterworks in Cincinnati, Portsmouth, and Ironton, Ohio, and Newport, Kentucky (Andrews, 1891; Bownocker, 1915).

The quarry industry in the vicinity of Buena Vista began to decline during the 1880s because of several factors. The great demand for the Buena Vista building stone earlier in the century had resulted in inferior grades being supplied to the market and the reputation for quality suffered. Additional factors that impacted stone production included competition from other building stones; the introduction of cement, especially for large projects such as bridges; increased stripping, and thus cost of production, as the quarries advanced into the hillside; and the uncertainty of river transportation, as this was an era before modern locks and dams had been constructed on the Ohio River, which made rail transport more attractive for building projects in major markets. The last of the stone companies in the southern Shawnee area, the Buena Vista Freestone Company, closed in 1909 (Bownocker, 1915).

The quarry industry in Scioto County did not disappear with the abandonment of the quarries at Buena Vista. In 1886, W. R. Smith & Sons opened a quarry at the village of Otway (north of Shawnee) to supply stone for the railroad near McDermott. This quarry did not enjoy long-term success, but a new quarry developed near McDermott in 1894 by Smith & Sons, and a second quarry opened in 1905 by the Waller Brothers (Bownocker, 1915; fig. 11), led to a successful quarry industry that continues into 2015. The Buena Vista Member at the Waller Brothers quarry consists of interbedded, very fine-grained sandstone, siltstone, and shale approximately 25 ft thick. The sandstone and siltstone are blue gray but weather to light yellow. Crushing strength is generally greater than 30,000 psi, which makes the stone suitable for a wide-range of building projects. The original market was very large; significant structures include the capitol at Alberta, British Columbia; Pickard Flats, Chicago; Johns Hopkins Hospital in Baltimore; and the Brown residence in New Orleans (Bownocker, 1915). The Waller Brothers currently market the Buena Vista Member for sills, coping, hearths, mantles, and laboratory tabletops, as well as traditional split-face **ashlar**. According to the Ohio Geological Survey industrial-minerals database, production from three quarries operated by Waller Brothers in Scioto County totaled more than 166,000 tons from 1996 through 2015.

Brick making

Though bricks are no longer made in the area, Portsmouth was home to a large ceramic industry for decades, beginning in the 1860s. The first fire brick plant was opened in 1865 at Sciotoville (annexed into Portsmouth in 1921). The Pennsylvanian (325–299 m.y.a.) Sciotoville clay was found to have excellent heat-resistant characteristics for manufacturing the brick that was used for lining kilns. By 1871, three firms consolidated to form the Scioto Fire Brick Company. A second operation, with the similarly sounding name of Scioto Star Fire Brick Company, opened in Sciotoville in 1872, with a capacity to produce 12,000 bricks each day (Stout and others, 1923).

The first fire brick plant at Portsmouth was constructed in 1873 by the Scioto Fire Brick Company. A second plant was built in 1882 by the Hocking Valley Fire Brick Company. This and another fire brick plant in Sciotoville were purchased by the Harbison-Walker Refractories Company in 1902 (Stout and others, 1923). Harbison-Walker is currently part of ANH Refractories and maintains manufacturing facilities in Ohio at Windham, Minerva, and Oak Hill.

The introduction at Malvern, Ohio, of an oversized, **vitrified** brick made from clay or shale changed the way streets were paved nationwide beginning in 1885. In 1892, the Portsmouth Paving Brick Company began

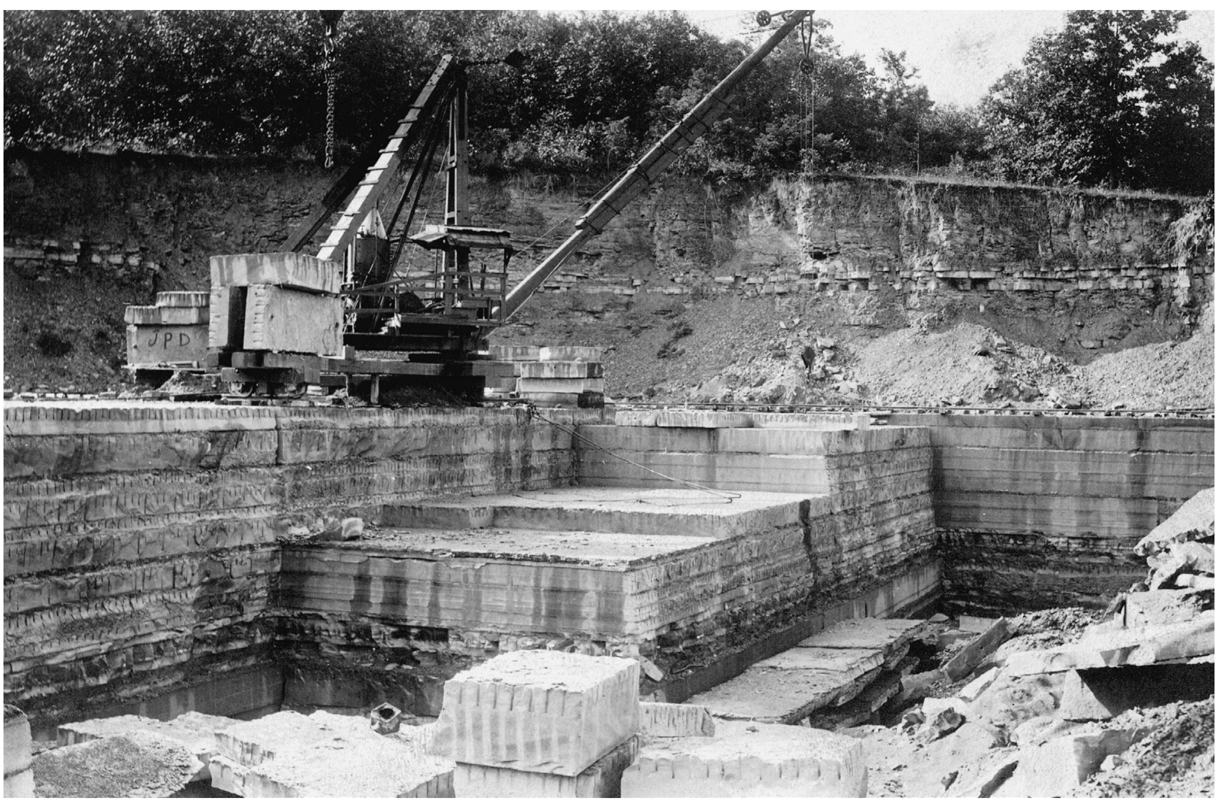

FIGURE 11.—Buena Vista Sandstone Member of the Cuyahoga Formation being quarried near McDermott, Ohio, northeast of Shawnee State Forest, *circa* 1920.

manufacturing paving bricks. The plant was so successful that many of the Portsmouth area fire brick plants converted some or all of their production to paving bricks. Manufacturers found that a mixture of seven parts Portsmouth Shale with two parts clay produced a paving brick with remarkable durability. Plants in Portsmouth and Sciotoville produced 7.5 million paving bricks in 1893 (Stout and others, 1923; Lamborn and others, 1938).

The Portsmouth area was part of an immense paving brick industry in Ohio. The annual production of paving brick in Ohio during 1893 is estimated to be more than 292 million, or enough pavers to cover 600 mi of road 25 ft wide (Stout and others, 1923; Lamborn and others, 1938; Blankenbeker, 1999). By the Depression years of the 1930s, road construction had changed dramatically, primarily using concrete and asphalt. Most Ohio paving brick plants closed or converted to other products. Ohio still has hundreds of miles of city streets paved with bricks, attesting to their durability and providing local charm. Since most paving brick companies embossed their bricks with the company name, logo, or commemorative design, many individuals find collecting pavers to be a rewarding hobby. Nearly 1,000 different types of branded paving brick have been identified from Ohio, with almost 100 attributed to Portsmouth-area brickyards (fig. 12; Blankenbeker, 1999).

Sand and gravel

The alluvial terraces along the Scioto and Ohio Rivers in Scioto County contain valuable deposits of sand and gravel. According to the Ohio Geological Survey industrial minerals database, more than 8 million tons of sand and gravel have been mined from these deposits since 1990. The sand and gravel is used primarily as an aggregate for road construction, building, asphalt mixes, and concrete. Since aggregate is a high-volume, low-cost material, having these deposits near population centers lowers the cost of transportation, making road construction and other development more cost effective.

Oil production

The organic content of the Ohio Shale in the Ohio River valley and the potential to produce oil from retorts was recognized during the mid-1800s. By the 1850s, a plant located at Buena Vista was producing 300 gallons (gal) per day of light oil from Ohio Shale mined nearby (Hoover, 1960). The discovery of petroleum in western Pennsylvania in 1859 and the discovery of oil in southeastern Ohio during the 1860s led to the end of the high-cost production of shale oil in the Ohio River valley. After the large increase in world oil

FIGURE 12.—Examples of paving bricks manufactured by the Portsmouth Paving Brick Company, Portsmouth, Ohio, during the early 1900s.

prices during the late-1970s, major oil companies began extensive exploration for oil shale resources in the United States. Philips Petroleum contracted with North American Exploration to drill a series of core holes in southern Ohio in 1980 to determine the feasibility of recovering shale oil from the Ohio Shale. The average Ohio Shale oil content in Scioto County cores was less than 10 gal per ton, thus commercial shale oil production was deemed not to be economically feasible.

Unusual Geologic Features

Lithology, joints, fractures, and slope, as well as physical and chemical weathering, have combined to create many rare and unusual geologic features in the Shawnee area, including rock tables and arches, caves, faults, rockfalls, and landslides. Four publically accessible sandstone arches are found in western Scioto County, and a number of dolomite arches in eastern Adams County are located on public land. There are also several arches on private property in both counties (Snyder, 2014). Dozens of rockfalls and landslides associated with Mississippian- and Devonian-age strata have been documented in southern Scioto County (for instance, see Davies and Mast, 1985). Caves can be found in the carbonates of eastern Adams County, including one of the longest mapped caves in Ohio. Cedar Fork Cave is located on the Davis Memorial State Nature Preserve and is publically accessible with a permit from the ODNR Division of Natural Areas and Preserves (Keller, 1984; Hobbs, 1986). Also exposed at Davis Memorial is a fault with 30 ft of displacement that juxtaposes the Silurian Pebbles Dolomite with the Greenfield Dolomite. This is one of only two known public areas in Ohio where faulting is clearly visible.

FIGURE 13.—Raven Rock, Scioto County, Ohio.

Scenic features

Raven Rock State Nature Preserve is located west of Portsmouth (fig. 1), Ohio, and offers spectacular views of the Ohio River valley from a high ridge (fig. 13). It was named for the rock outcrop's resemblance to a bird (some imagination is required). The Shawnee tribe would have no doubt used this vantage point for early observation of travelers on the river, or possibly overland, as the Portsmouth area was located on two important inland trails: Warrior Path, from Lake Erie to the Cumberland Gap, and Pickawillany Trail, which started at the mouth of the Scioto River and ended at Peckuwe, near present-day Springfield, Ohio. The Native Americans may have been intrigued also by the four amazing rock arches that can be found near Raven Rock: Raven Rock Arch, Rockgrin Arch, Slide Arch, and The Penthouse (Snyder, 2009).

Typical rock arches or bridges are formed when softer portions of competent rocks, such as sandstones, limestones, dolomites, and siltstones, are eroded by water or wind and form rock shelters on the opposite side of an outcrop. With the passage of time, the less competent rock is eroded completely away, forming the arch. Sometimes joints or fractures allow water to infiltrate, and the expansion and contraction effects associated with freeze-thaw cycles will contribute to the formation of the arch. Many times rockfalls will indicate the presence of a failed or collapsed arch.

Raven Rock Arch (fig. 14) has a span of 15 ft, a clearance of 7 ft, and is just over 1 ft wide at its narrowest point (Snyder, 2009). Rockgrin Arch is much smaller, with a span of 5 ft and a clearance of a little more than 1 ft. Slide Arch has a span of 3.6 ft and a clearance of 5 ft; the delicate lintel is only two inches thick, which is the narrowest of all Ohio arches (Snyder, 2009). The Penthouse is a type of arch called a *rock house*. Rock House, in Hocking Hills State Park in Hocking County, Ohio, is a striking example of this type of arch, with 25-ft high ceilings and a 200-ft long by 30-ft wide main corridor. The Penthouse is tiny by comparison, with a 3-ft span and only a 1-ft clearance (Snyder, 2009). All the arches at Raven Rock were formed in the Mississippian Logan Formation.

FIGURE 14.—Raven Rock Arch, Scioto County, Ohio.

The sixteen documented arches in Adams County include several on state lands. Shoemaker State Nature Preserve, located in northeastern Adams County, contains four arches: Cedar Fork Arch, Mattress Arch, Crawl Arch, and Blocked Arch. Cedar Fork Arch has a span of 6.5 ft and a clearance of 14 ft; the other three arches are smaller. All the arches at Shoemaker were formed in the Silurian Peebles Dolomite (Snyder, 2014).

Geologic hazards

Karst is the term used for landscape formed from the dissolution of soluble rocks, such as limestone and dolomite, and it is characterized by sinkholes and cave formation. More than 500 known and probable karst features have been mapped in eastern Adams County, Ohio (Pavey and others, 1999b). By 2010, the Wittenberg University Speleological Society (WUSS) had documented 28 caves in Adams County, including the longest mapped, non-commercial cave in the state, Freeland's Cave (Hobbs, 1986; WUSS, 2010). Freeland's Cave is located on private property in Meigs Township, Adams County, near the northwest boundary of Shawnee State Forest. Freeland's Cave is more than 2,300 ft long with wet, typically small, winding passages that are joint-controlled in the Pebbles Dolomite. The cave features at least two large rooms with 13-ft high ceilings located approximately 800 ft into the cave. Portions of the cave are lined with unusual tabular gypsum ($CaSO_4 \bullet H_2O$). The surface surrounding the cave has numerous sinkholes; some are thought to have connections with the subsurface allowing water to easily enter the cave system (Hobbs, 1986).

Earth movements (landslides, debris flows, and rockfalls) are a common occurrence in southern Ohio because of the steep terrain; relatively high rainfall amounts; and the interbedding of less competent rock types, such as shale and claystone, with more competent rock types, such as sandstone, siltstone, and dolomite. Water is a major factor: clay minerals in the shale will attract (**adsorb**) water molecules to their surfaces; the water then acts as a lubricant, allowing the clay minerals to more easily "slide" past each other. The weight of the water also acts as an additional load that, in the absence of mitigating factors such as deep-rooted vegetation or shallow slopes, will exceed the ability of the bedrock to maintain the current degree of slope, leading to an earth movement. The Sunbury Shale and the Ohio Shale are most susceptible to earth movements in the Shawnee region; slides occur in the Estill Shale farther to the west.

Highway and secondary road construction that includes road cuts in the steep terrain can increase the number of landslides, both from slope oversteepening and improper drainage controls. Many hillsides along U.S. Rte. 52 west of Portsmouth contain historic landslides; active landslides were documented in at least 19 areas along the highway in 1985 (Davies and Mast, 1985; Mast, 1985). The potential for rockfalls are indicated along U.S. Rte. 52 in eastern Adams County, where the Peebles Dolomite outcrops in high vertical cliffs. Additional areas with multiple mapped landslides or rockfalls include Scioto Brush Creek and its tributaries, Pond Lick Rd., and Upper Twin Creeks Rd.

Earthquakes are a rare event in the Shawnee area, but they do occur. At least 5 felt earthquakes have occurred since 1877 in the region; the largest was a magnitude 4.2 that struck Portsmouth early in the morning on May 17, 1901 (Hansen, 2014). The tops of many chimneys were damaged, dishes thrown from shelves, and windows shattered. The earthquake was felt over a large area of Ohio, Kentucky, and West Virginia, but no serious damage or injuries were reported.

Geology and Ecology

There is a saying in the mining industry: "If it can't be grown, it has to be mined." This phrase illustrates the essential nature of the earth to sustain life. Take a moment and try to name one object that you came into contact with today that was not grown, sustained by plant or animal life, or manufactured using raw materials that were produced by an extractive process. A geologist would take the idea further: "Without geology, it couldn't be mined or grown." Even something as essential to life as water, including the hydrologic cycle, is predominantly influenced by the regional geology. The underlying geology, combined with climate history, determines slope aspect and soil types. Certain plants and animals have a preference for particular habitats that, outside of human impacts, are predominantly controlled by the regional geology.

The Shawnee region is recognized nationally for its ecological significance. The area has been described as "Ohio's greatest remaining wilderness," and it has been noted that the "biological diversity of Shawnee is tremendous, possibly unrivaled in Ohio" (McCormac and Mesazaros, 2009). The Rocky Hollow area of Shawnee has been evaluated as a potential National Natural Landmark (Moser, 1982). The **mesophytic** forest association is considered the near northwestern-most outlier of Smoky Mountain cove forests. The eminent forest ecologist, Emma Lucy Braun, who studied geology and botany at the University of Cincinnati, recognized the importance of geologic processes in woodland development. Braun's classifications of forests in eastern North America, and the subsequent research of others, label the Shawnee region as part of the largest and most-diverse forested areas in the eastern United States, containing 162 species of trees (Dyer, 2006). The Teays River system acted as a corridor for plants and animals to migrate northward as the climate changed. Today, the Shawnee area is considered the finest habitat in Ohio for reptiles and amphibians and harbors 24 plant species that are rare in the state (Moser, 1982).

The bedrock geology of the Shawnee region varies from sandstone and siltstone dominating in the east to shale and dolomite more prominent in the west. This variation in bedrock is accompanied by a change in the vegetation. The plants and animals that prefer particular habitats thrive because of these ecosystem changes. An example is the green salamander (*Aneides aeneus*) that is endangered in Ohio and rare throughout its range. Green salamanders live in cracks and shallow caves (karst) in moist dolomite cliffs, such as those found in the western Shawnee region and especially farther to the west at the Edge of Appalachia Preserve System. The female green salamander lays eggs that she attaches to the roof of a crevice and stands guard over the eggs for up to three months until they hatch (Chris Bedel, Edge of Appalachia Preserve System, oral commun., 2014). More than 69 species of land snails, the North American giant millipede, the Allegheny woodrat ("packrat"), and many rare plants, spiders, and lichens are associated with the dolomite cliffs of Adams County, Ohio.

FIELD GUIDE TO THE GEOLOGY OF THE SHAWNEE REGION, SCIOTO AND ADAMS COUNTY, OHIO

Introduction

A lack of continuous rock exposures in Shawnee State Park and surrounding State Forest is typical of southern Ohio, where excellent **lithologic** sections are normally limited to highway or railroad cuts, active mines and quarries, or excavations associated with commercial developments. The bedrock geology of relatively thin-bedded sandstone, siltstone, and shale in the majority of the Shawnee region has created steep slopes covered with colluvium, resulting in few natural outcrops. Thick-bedded to massive dolomite that is resistant to weathering occurs in the extreme southwestern portion of the State Forest, allowing good access to view a portion of the Silurian strata. Most other rock exposures are limited to stream beds and an occasional forest road excavation into the hillside. The primary advantage of rock exposures on public land is the continuous and safe availability to students and ordinary citizens in which exploration and discovery of new geologic features can be accomplished by the inquisitive individual.

The challenge of solving the mystery of an area's geology can be similar to completing a puzzle, with two caveats: (1) there are always missing pieces to the puzzle (lack of continuous outcrops); and (2) occasionally someone bumps the table and mixes up the pieces (new geologic models or information). An understanding of the geology of the Shawnee region requires the use of all the sources of public information available, including published geologic maps and reports, geologic field-trip guides, Master's theses or Ph.D. dissertations that investigate the local geology, measured sections and core descriptions on file at the Ohio Geological Survey, and field observations. Another source of more generalized geologic data can be found in the ODNR Division of Water Resources water well database that is available online[1]. The geologic information gathered in the field is fragmental but when combined with other sources of information, can depict the regional geology with reasonable accuracy. A few exposures of key geologic units outside the State Forest boundaries are included in this field guide so that those interested in the geology of southern Ohio can more fully understand its geologic complexities. For those interested in the geology of nearby areas in Kentucky, the interactive statewide geologic map maintained by the Kentucky Geological Survey offers an excellent overview; the map can be accessed at **http://www.uky.edu/KGS**.

Recommendations for Geologic Field Study

The professional geologist or amateur naturalist uses all necessary safety precautions when visiting areas where rocks are exposed at the surface. This geologic field guide has concentrated on the thousands of acres of publically accessible areas within Shawnee State Park and State Forest. Permission should always be obtained before entering private property; look for yellow blazes on trees that delineate the State Forest boundary.

Sites with exposed rock units may include areas along public roads. If you cannot completely pull off the traveled portion of the road nearby, DO NOT STOP; you may find a more suitable parking area within a short walk. You then may safely return to the site of interest by foot. Wearing brightly colored safety vests and hardhats are recommended, especially along more heavily traveled roadways.

This cannot be stressed enough: NEVER CLIMB ON OUTCROPS. Wear sturdy shoes and always know where your hands and feet are contacting the earth's surface. If you begin to feel uncomfortable, you should retreat to a safer location. Be aware of slipping hazards, such as wet leaves or soils and unstable, loose, or wet rocks. Whenever possible, have someone accompany you on your geologic investigations; it's safer, as well as more fun, to share the experience. Individuals should carefully assess any hazards so essential geologic elements can be more closely observed without endangering your well-being. High-quality photographs, taken using a telephoto lens combined with a common object for scale (e.g., coin, ruler, glove, camera case, hat, person, vehicle) can be studied in detail later. COLLECTING OF ROCKS, MINERALS, OR FOSSILS IN STATE PARKS AND STATE FORESTS WITHOUT A PERMIT IS AGAINST THE LAW. All collecting should be done only with the permission of the landowner (in this case, State of Ohio, Department of Natural Resources) and is not encouraged unless as part of a scientific investigation. Remember, these public lands belong to all Ohioans, especially future generations.

[1] Visit **http://water.ohiodnr.gov**.

How to Use this Field Guide

Each of the following site descriptions includes general location information (and address, where applicable), latitude (lat) and longitude (long) coordinates, site elevation above mean sea level (m.s.l.), and the name of the site, along with road names for reference. The site descriptions can be used in conjunction with figure 15 and the plate that accompanies this publication to help explorers locate each of the sites and to aid in understanding what can be observed there. It is not intended that all of the following sites be visited in one day, because of the large number and their degree of adjacency to one another.

Also provided are the names of the USGS 7.5-minute (1:24,000-scale) topographic quadrangles where each site may be found. Topographic maps, especially at this scale, are particularly useful for hiking, hunting, fishing, and further exploring an area as they provide a wealth of information, including land elevation, natural features, cities and towns, buildings and infrastructure, and pits and quarries. Topographic maps can be obtained by visiting the ODNR Division of Geological Survey, Geologic Records Center in Columbus or by calling (614) 265-6576 or emailing **geo.survey@dnr.state.oh.us**.

Site 1 – Shawnee Lodge and Conference Center, Scioto County

4404 State Rte. 125
Portsmouth, Ohio 45663
http://shawneeparklodge.com
Coordinates: lat 38°44′23.6″N., long 83°12′13.3″W.
Elev. 977 ft above m.s.l.
Pond Run 7.5-minute quadrangle

For visitors interested in the natural history and geology of the Shawnee area, a wonderful place to base a day trip or multiday exploration is the Shawnee State Park Lodge and Conference Center. The Shawnee Lodge offers 50 guest rooms and all the amenities that visitors expect from the nationally recognized Ohio State Parks system. There are also 25 nearby cottages that each sleep up to six, including two premium cottages and four pet-friendly cottages. For a preview of the surrounding geology, the lodge has been landscaped with sandstone and siltstone slabs obtained locally that contain marvelous examples of some of the sedimentary structures and trace fossils (**ichnofossils**) found in the Shawnee area. Ichnofossils include tracks, burrows, trails, borings, fossilized waste, and other indirect evidence of once-living organisms. The lodge entrance exhibits incredible examples of *Zoophycos* (fig. 10), a trace fossil that resembles a rooster's tail and that was probably made

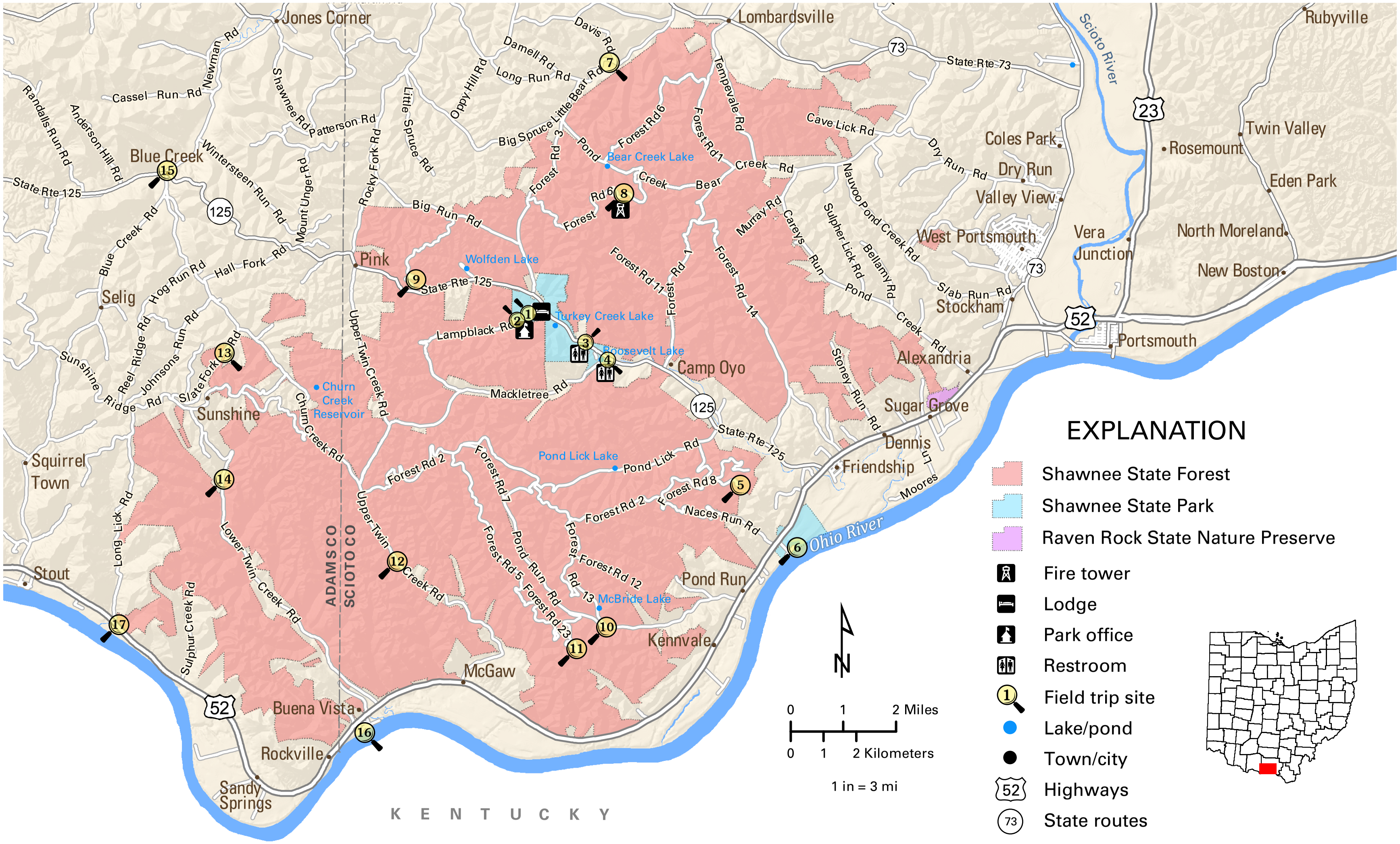

FIGURE 15.—Map of Shawnee State Park and State Forest region in Ohio showing sites of geologic interest. See table 1 for a listing of the sites including names, latitude and longitude, and geologic units.

TABLE 1. ***Field trip stops at Shawnee State Park and State Forest***[1]

Site	Location Name[2]	Geology[3]	Latitude/Longitude[4]
1	Shawnee S.P. Lodge and Conference Center	Mississippian Cuyahoga and Logan Formations[5]	lat 38°44'23.6''N., long 83°12'13.3''W.
2	Shawnee S.P. Lodge Rd.	Mississippian Cuyahoga Fm, Logan Fm, and Sunbury Shale, Devonian Berea Sandstone	lat 38°44'20.8''N., long 83°12'26.6''W.
3	Ohio S.R. 125 near Turkey Creek Lake Dam	Mississippian Cuyahoga Formation	lat 38°43'56.6''N., long 83°10'59.5''W.
4	Roosevelt Lake	Devonian Berea Sandstone	lat 38°43'42.2''N., long 83°10'37.2''W.
5	Picnic Point	Mississippian Logan Formation	lat 38°41'22.6''N., long 83°07'40.1''W.
6	Shawnee S.P. Marina and Golf Course	Pennsylvanian Massillon sandstone[5]	lat 38°40'39.0''N., long 83°06'33.8''W.
7	Alum Rock	Devonian Berea Sandstone and Bedford Shale	lat 38°48'36.4''N., long 83°10'38.6''W.
8	Copperhead Fire Tower	Mississippian Logan Formation	lat 38°46'21.7''N., long 83°10'16.7''W.
9	Shawnee S.F. Rd. 6	Mississippian Logan Formation	lat 38°44'57.8''N., long 83°14'33.4''W.
10	McBride Lake	Devonian Berea Sandstone	lat 38°39'14.0''N., long 83°10'29.3''W.
11	Shawnee S.F. Rd. 5 road cut, overlook, and Grass Lick Bridle Trail	Devonian Berea Sandstone, Mississippian Cuyahoga Fm, Logan Fm, and Sunbury Shale	lat 38°38'51.0''N., long 83°11'11.4''W.
12	Upper Twin Creek	Devonian Berea Sandstone and Bedford Shale	lat 38°40'10.7''N., long 83°14'51.0''W.
13	Churn Creek	Mississippian Sunbury Shale	lat 38°43'39.4''N., long 83°18'38.2''W.
14	Lower Twin Creek	Devonian Ohio Shale	lat 38°41'38.0''N., long 83°18'36.7''W.
15	Village of Blue Creek	Devonian Ohio Shale	lat 38°46'39.0''N., long 83°19'50.9''W.
16	Village of Buena Vista	Mississippian Cuyahoga Fm and Logan Fm, Devonian Berea Sandstone[5]	lat 38°37'28.2''N., long 83°15'43.2''W.
17	Long Lick Run	Silurian Lilley Fm, Peebles Dolomite, and Estill Shale	lat 38°39'13.0''N., long 83°20'48.1''W.

[1]This list does not convey permission to visit privately owned sites or restricted areas of publicly owned sites. Proper permission and any required permits must be obtained before visiting. Please contact the appropriate agency, business, or land owner in advance.
[2] S.F. = State Forest, S.P. = State Park, S.R. = State Route
[3] Fm = Formation.
[4] Coordinates are approximate.
[5] Rock unit used in structure or exhibit.

by soft-bodied worm-like, sediment-feeding animals; and *Helminthopsis* (fig. 16), often called "curly worm tubes," which are very simple, small, sinuous feeding burrows (Feldman and Hackathorne, 1996). A spectacular example of a typical locomotion trail, perhaps of a bivalve (clam) or gastropod is preserved in a siltstone slab (fig. 17; Dan Hembree, Ohio University, written comm., 2014). The remarkable multicolor swirls and banding found in several stone slabs are often referred to as Liesegang banding (fig. 18). This colorful banding is the result of complex chemical reactions of iron and other trace elements dissolved by surface water or groundwater that flowed through the rocks.

Ichnofossils can be found throughout the Shawnee area but are most prevalent in the Mississippian-age siltstones of the Cuyahoga and Logan Formations (Middleman, 1976). Ichnofossils have the advantage of often being preserved in **clastic** rocks where body fossils are rare. **Diagenesis** can destroy or distort body fossils but has little effect on trace fossils. A very important use of trace fossils is the reconstruction of the environment in which creatures lived for **paleoenvironmental** interpretations. Ichnofossils have been used to help determine where a building stone originated, which could be significant to local economic history or for accurate architectural restoration (Hannibal, 1995). Careful observation and examination of trace fossils can be powerful tools for determining when and how particular geologic formations were formed, especially when used in conjunction with detailed lithologic descriptions, sedimentary structures, and other paleontological occurrences (Knaust and Bromley, 2012).

Site 2 – Shawnee State Park Lodge Road, Scioto County

Coordinates: lat 38°44′20.8″N., long 83°12′26.6″W.
Elev. range 745–880 ft above m.s.l.
Pond Run 7.5-minute quadrangle

The road to Shawnee State Park Lodge from State Rte. 125, at the northern end of Turkey Creek Lake, covers a distance of more than 4,000 ft and is constructed mostly through the Cuyahoga and Logan Formations. The contact of the Sunbury Shale with the Berea Sandstone can be found at stream level and marks an important geologic time boundary between the Mississippian and Devonian Periods. A small shale exposure at a drain outflow on the north side of the lodge road is the contact of the Buena Vista Member of the Cuyahoga Formation with the upper

FIGURE 16.—The ichnofossil, *Helminthopsis*, is often described as "curly worm trails." This example can be found on a siltstone slab at the entrance to Shawnee State Park Lodge, Scioto County, Ohio. *Helminthopsis* is common in the Logan and Cuyahoga Formations throughout the Shawnee area.

FIGURE 17.—Ichnofossil found on a siltstone slab at the entrance to Shawnee State Park Lodge, Scioto County, Ohio. The form is typical of a locomotion trail of a bivalve or gastropod moving through soft sediment below the sea surface.

FIGURE 18.—Stone bench on the grounds of Shawnee State Park Lodge, Scioto County, Ohio, displaying the multicolor stripes and swirls typical of Liesegang banding. Liesegang banding is the result of complex chemical reactions of iron and other trace elements dissolved by surface water and groundwater that flowed through the rocks.

portion of Sunbury Shale. A relatively thick sequence of fine-grained sandstones and siltstones encountered on the western side of the road, approximately 2,500 ft west of Turkey Creek Lake, is the Byer Member of the Logan Formation. This easily accessible locality provides an opportunity to thoroughly examine the lower portion of the Logan. Look for trace fossils and possibly body fossils (brachiopods and bryozoans) near the top of the hill. Be cautious of traffic on the lodge access road, do not climb the rock faces, and always be aware that overhanging rocks can be dislodged and cause harm to those underneath.

Site 3 – Ohio State Rte. 125 near Turkey Creek Lake Dam, Scioto County

Coordinates: lat 38°43′56.6″N., long 83°10′59.5″W.
Elev. 750 ft above m.s.l.
Pond Run 7.5-minute quadrangle

An exposure of the Buena Vista and Henley Members of the Cuyahoga Formation can be found 0.3 mi southeast of Turkey Creek Lake Dam on the northwest side of Ohio State Rte. 125. A wide pull-off allows safe access to the rock outcrop that extends more than 200 ft and is approximately 20 ft high (fig. 19). The Buena Vista Member displays the typical, very thick (8–14 in), continuous bedding that makes it an excellent building stone. Widely spaced vertical fractures can be observed; the fractures allowed large blocks of the hard, very fine-grained sandstone and siltstone to be quarried more easily. The ichnofossil, *Zoophycos*, is conspicuous in several of the large stone blocks that have fallen from the rock face. Approximately 4 ft of the underlying, medium-gray shale of the Henley Member can be seen at the base of the outcrop.

Site 4 – Roosevelt Lake, Scioto County

Coordinates: lat 38°43′42.2″N., long 83°10′37.2″W.
Elev. 671 ft above m.s.l.
Pond Run 7.5-minute quadrangle

The dam at Roosevelt Lake was being reconstructed during the fall of 2014, and the lake had been drained, allowing access to an outcrop of Berea Sandstone that was normally partially flooded. The Berea at this location is a thick- to very thick-bedded, fine- to medium-grained sandstone with thin shale interbeds. Soft sediment deformation characterized by "ball and pillow" structure is prominent (fig. 20), as are ripple marks. Approximately 0.5 mi to the west, a major tributary to Roosevelt Lake cuts through the Berea Sandstone at an elevation of 680 ft above m.s.l. A very thick bed of sandstone underlain

FIGURE 19.—Contact between the overlying Buena Vista Member and the underlying Henley Shale Member of the Cuyahoga Formation. The site is located east of State Rte. 125 and 0.3 mi south of Turkey Creek Lake Dam, Shawnee State Park, Ohio. The surveying rod is 5 ft high.

by several feet of shale has created a small shelter cave on the north side of the stream. A large semi-circular pull-off associated with a nearby horseback trail provides easy access to the stream and outcrops, though high boots will be needed to wade the stream for close inspection of the outcrop.

Site 5 – Picnic Point, Scioto County

Coordinates: lat 38°41′22.6″N., long 83°07′40.1″W.
Elev. 1,090 ft above m.s.l.
Pond Run 7.5-minute quadrangle

Picnic Point is accessed from Shawnee Forest Rd. 1 (Pond Lick Rd.), approximately 1 mi west of State Rte. 125, climbing nearly 500 ft along Shawnee Forest Rd. 9 to a large, circular turn-around with ample parking. The overlook of the Ohio River valley and the view to the east at Portsmouth gives the viewer an appreciation for the geologic forces that created this vital waterway that was important to historical settlement as well as present-day commerce (fig. 21).

Approximately 0.75 mi west of Picnic Point on Shawnee Forest Rd. 8, immediately west of Shawnee Forest Rd. 9, is a small pull-off to a logging road. The cut along this logging access road exposes about 100 ft of vertical section of the Logan Formation. As you walk up the hill, fossiliferous zones, trace fossils, and some ripple marks can be observed in the medium-bedded siltstone and minor interbedded shales.

Site 6 – Shawnee State Park Marina and Golf Course, Scioto County

Coordinates: lat 38°40′39.0″N., long 83°06′33.8″W.
Elev. 530 ft above m.s.l.
Friendship 7.5-minute quadrangle

The Shawnee State Park Marina and Golf Course, located south of U.S. Rte. 52, are not only recreational centers for boat owners and golfers, but they also offer a chance for the explorer to recharge. Tables overlooking the marina and Ohio River can be used for picnics;

FIGURE 20.—An example of ball-and-pillow sedimentary structure in the Berea Sandstone exposed on the north shore of Roosevelt Lake, Shawnee State Park, Ohio. The total thickness of Berea exposed is approximately 10 ft.

FIGURE 21.—View looking eastward toward Portsmouth, Ohio, and the Ohio River valley from Picnic Point, Shawnee State Forest, Ohio.

well-maintained rest rooms are also available. As always, geology surrounds you. The Ohio River flows across the Ohio Shale (not exposed) at this locality. River barges carrying coal, for electric-generating stations along the river, or other geologic bulk commodities are a common sight. Note the building stones used in the construction of the marina building. The multicolored sandstone is typical of the Pennsylvanian Massillon sandstone quarried by the Briar Hill Stone Company in Coshocton County, Ohio (fig. 22).

Site 7 – Alum Rock, Scioto County

Coordinates: lat 38°48′36.4″N., long 83°10′38.6″W.
Elev. 690 ft above m.s.l.
Otway 7.5-minute quadrangle

Alum Rock is located on private property, north of County Rd. 41 (Big Spruce Rd.), approximately 1 mi south of State Rte. 73 where a bridge crosses Bear Creek. Alum Rock likely is named for the mineral potash alum ($KAl(SO_4)_2 \cdot 12H_2O$), which is known to occur along bedding planes of the Berea Sandstone along Scioto Brush Creek (Carlson, 2015; Milam, 2016). A small pull-off (see coordinates above) allows one to safely view the nearly

FIGURE 22.—Columns of multicolored sandstone at the Shawnee State Park Marina in Scioto County, Ohio, are typical of the Pennsylvanian Massillon sandstone quarried by Briar Hill Stone Company in Coshocton County, Ohio.

60 vertical feet of massive, fine-grained sandstone cliffs that outcrop along the creek, particularly when the foliage is not present (fig. 23). Typically, the Berea Sandstone and underlying Bedford Shale would contain thick-bedded sandstone with increasing siltstone and shale interbeds downward, but at this locality the Berea/Bedford contact cannot be distinguished. This massive sandstone may represent a localized, nearshore marine depositional environment, such as a barrier bar.

Site 8 – Copperhead Fire Tower, Scioto County

Coordinates: lat 38°46′21.7″N., long 83°10′16.7″W.
Elev. 1,286 ft above m.s.l.
Otway 7.5-minute quadrangle

The Copperhead Fire Tower is located on Shawnee Forest Rd. 6, approximately 2 mi south (by road) from Bear Lake in the northeastern portion of Shawnee State Forest. A large parking area is located 600 ft west of the fire tower and offers an unobstructed view to the north and northwest. If you are adventurous, as well as in reasonably good physical condition, a climb to the top of the 60-ft tall tower will reward you with a spectacular 360-degree view of the surrounding terrain.

The Copperhead Fire Tower was constructed in 1924 and was the first fire tower built in Ohio. It was staffed for more than 50 years for early detection of forest fires. Aircraft became the primary focus for early detection of fires beginning in the 1940s, and the staffing of Ohio fire towers was completely phased out in 1978. The Copperhead Fire Tower was restored in 2013 and is one of only 20 fire towers that remain in Ohio.

The fantastic view from the top of the tower allows one to survey landforms that are representative of the unglaciated Appalachian Plateau to the east and south and the Allegheny Escarpment to the north and west. The Appalachian Plateau in the Shawnee area consists of siltstones, sandstones, and shales of Mississippian age with a shallow dip to the southeast. The Allegheny Escarpment marks the boundary between the unglaciated and glaciated Appalachian Plateau and is generally defined by the nearly 160-ft-thick Berea Sandstone and the underlying sandstone, siltstone, and shale of the Bedford that outcrop in a northeast–southwest trend several miles west of the tower. The Copperhead Fire Tower is located on the Logan Formation; siltstone and fine-grained sandstone **"float"** can be seen along the path up to the tower and along the horse trail to the south. These rock units are more resistant to erosion, forming ridges and very steep slopes with narrow valleys.

FIGURE 23.—Cliffs of Berea Sandstone and Bedford Shale along Bear Creek, Scioto County, Ohio. The massive sandstone probably represents a localized nearshore depositional environment, such as a barrier bar.

Site 9 – Shawnee Forest Rd. 6, Scioto County

Coordinates: lat 38°44′57.8″N., long 83°14′33.4″W.
Elev. 1,217 ft above m.s.l.
Otway 7.5-minute quadrangle

Along Shawnee Forest Rd. 6, a road cut approximately 250 ft long and 10 ft high exposes fine-grained sandstones, siltstones, and shales of the Vinton Member of the Logan Formation. A small pull-off on the east side of the road allows safe access to view the exposure in more detail. Trace fossils are abundant and occasionally a body fossil such as a brachiopod can be seen.

Site 10 – McBride Lake, Shawnee Forest Rd. 1 and Forest Rd. 13, Scioto County

Coordinates: lat 38°39′14.0″N., long 83°10′29.3″W.
Elev. 666 ft above m.s.l.
Pond Run 7.5-minute quadrangle

The enterprising individual can view an interesting combination of Berea Sandstone "pavement" and substantial blocks of cut sandstone from the Buena Vista Member of the Cuyahoga Formation near a stream along Shawnee Forest Rd. 1.

Site 10 is a pull-off on the north side of the bridge that crosses Pond Run Creek at the intersection of Shawnee Forest Rd. 1 and Shawnee Forest Rd. 13, three miles west of U.S. Rte. 52. The Berea is exposed in the stream bed during low-water periods and the cut sandstone is used as rip-rap to control erosion along the outside bank. The bridge abutments also are a striking example of the workmanship of the CCC laborers during the 1930s.

The upper portion of the Berea, exposed for several hundred feet in Pond Run Creek northwest of the bridge, has been differentially eroded into a slightly undulating surface in which more resistant iron-rich "nodules" protrude above the surface of the sandstone. Ripple marks are common. The surface of the Berea is broken into slabs of various sizes by well-developed joints trending northeast–southwest. A conjugate set of joints further dissects the surface (fig. 24).

FIGURE 24.—The Berea Sandstone exposed in Pond Run Creek near McBride Lake, northwest of the intersection of Shawnee State Forest Rds. 1 and 13, Scioto County, Ohio. The Berea at this location displays differential weathering and a strong northeast-to-southwest–trending joint pattern.

Site 11 – Shawnee Forest Rd. 5 Road Cut, Overlook, and Grass Lick Bridle Trail, Scioto County

Coordinates: lat 38°38′51.0″N., long 83°11′11.4″W.
Elev. range 1,050–1,160 ft above m.s.l.
Pond Run 7.5-minute quadrangle

Shawnee Forest Rd. 5 intersects with Shawnee Forest Rd. 1 approximately 3.5 mi west of U.S. Rte. 52 and traverses the Berea Sandstone, Sunbury Shale, Cuyahoga Formation, and the Logan Formation as the road ascends nearly 500 ft in elevation. A wide corner pull-off, 1.1 road mi south of Shawnee Forest Rd. 1, allows safe access to view a section of the Logan Formation greater than 30 ft thick that extends more than 300 ft south along Shawnee Forest Rd. 5 (fig. 25). The Logan Formation at this point is a series of siltstones and very fine-grained sandstones with minor, silty shale interbeds, medium to thick bedded (2–4 in thick), in a repetitive sequence. Fossils such as brachiopods and crinoids can be found but are sparse. Trace fossils such as *Zoophycos* are abundant in many areas. This location is interpreted to be located at or near the top of the Byer Member of the Logan Formation.

Proceed 0.3 mi farther south on Shawnee Forest Rd. 5 until a parking area with a scenic view to the south is reached. The deeply entrenched Ohio River valley with the steep, heavily forested hills nearby and southward into Kentucky can be seen at this point. Access to outcrops of a highly fossiliferous zone within the Vinton Member of the Logan Formation can be reached by walking south along the nearby Grass Lick Bridle Trail. Fossils such as brachiopods and pelecypods are common though not always well preserved because of the somewhat higher-energy environment in which the siltstone was deposited. Gastropods, cephalopods, corals, and an extremely rare Mississippian-age trilobite may also be found (fig. 26). Though not all fossil species associated with the Logan Formation have been recognized in Scioto County, 79 species dominated by brachiopods and pelecypods have been found in the Logan statewide (Fagadau, 1952; Feldman and Hackathorn, 1996). One species of brachiopod that is found 25–40 ft above the base of the Vinton (*Dictyclastus agmenis*) has been correlated from Licking County in central Ohio into Kentucky (Fagadau, 1952).

The predominance of very fine-grained sandstones, siltstones, and shales, as well as the fossil evidence, indicate the Vinton Member of the Logan Formation was formed in a marine shelf environment below wave depth.

FIGURE 25.—Road cut on Shawnee State Forest Rd. 5, Scioto County, Ohio. Exposed is the top of the Byer Member of the Logan Formation. Note the repetitive, medium- to thick-bedded, sparsely fossiliferous siltstone beds that indicate a marine shelf depositional environment. The surveying rod is 5 ft high.

The fine-grained sediments supplied by rivers and streams would be carried farther offshore before being deposited. Brachiopods were among the most abundant marine filter feeders and reef builders during the Mississippian Period, preferring warm waters and avoiding strong currents and waves. Pelecypods (bivalves), similar to today's clams or oysters, were also filter feeders that preferred a quiet-water environment. Gastropods were considered predators, often leaving evidence of borings into the outer shells of bivalves and brachiopods to reach the soft, inner bodies to obtain food. The majority of the Logan Formation in the Shawnee region does not contain preserved fossils, indicating a more **turbid** environment in the shallow Mississippian-age seas that was not favorable for the widespread development of bottom-dwelling organisms. Preservation of fossils also was poor because of replacement of shell materials by iron minerals, such as limonite or goethite (Hansen, 2001).

Site 12 – Upper Twin Creek, Scioto County

Coordinates: lat 38°40′10.7″N., long 83°14′51.0″W.
Elev. 780 ft above m.s.l.
Pond Run 7.5-minute quadrangle

The Berea Sandstone and Bedford Shale outcrop along Upper Twin Creek beginning approximately 2 mi north of U.S. Rte. 52 on County Rd. 96. The Ohio Shale is exposed on private property along the south side of the stream. A bridge/stream crossing of Upper Twin Creek exposes the Berea Sandstone in the streambed. A small but scenic waterfall tumbles over the Berea a few hundred yards south of the bridge (fig. 27).

Site 13 – Churn Creek, Adams County

Coordinates: lat 38°43′39.4″N., long 83°18′38.2″W.
Elev. 830 ft above m.s.l.
Buena Vista 7.5-minute quadrangle

The Sunbury Shale is found along a tributary to Churn Creek on Adams County Rd. 4 approximately 2 mi northwest of Churn Creek Lake. Small earthflows and slumping are common in the Sunbury on the hillside south of the road. The black, organic-rich shale is exposed in the stream for approximately 2,100 ft north of County Rd. 4. Both of the contacts with the overlying Cuyahoga Formation and the underlying Berea Sandstone are hidden, but they can be approximated by the first appearance of coarser-grained sediments exposed in the stream. The Sunbury Shale is approximately 50 ft thick at this location. Joint patterns in the stream bed trend N. 60° W. and N. 40° E. (fig. 28).

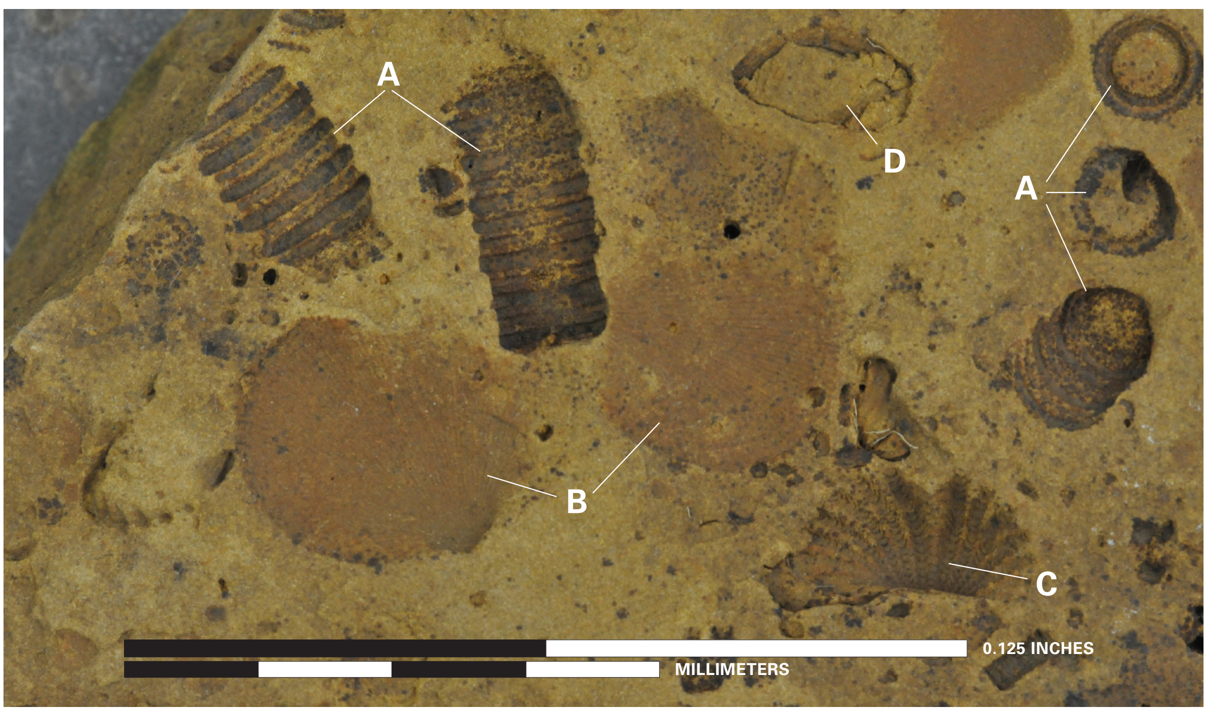

FIGURE 26.—Close-up photo of fossil preservation commonly found in siltstones of the Logan Formation in Scioto County, Ohio. Sample from Grass Lick Bridal Trail, near Shawnee State Forest Rd. 5. Fossils shown include (A) crinoid stem sections, (B, C) brachiopods, and (D) a possible gastropod.

FIGURE 27.—The Berea Sandstone can create small, picturesque waterfalls, such as this one on Upper Twin Creek in Shawnee State Forest, Ohio.

FIGURE 28.—The Sunbury Shale exposed in the stream bed of a tributary to Churn Creek, north of County Rd. 4, Shawnee State Forest, Ohio. The thin-bedded, organic-rich shale of the Sunbury contains intersecting joint sets.

Site 14 – Lower Twin Creek, County Rd. 4, Adams County

Coordinates: lat 38°41′38.0″N., long 83°18′36.7″W.
Elev. 750 ft above m.s.l.
Buena Vista 7.5-minute quadrangle

Approximately 6 mi north of U.S. Rte. 52 on Adams County Rd. 4, the Ohio Shale is exposed along Lower Twin Creek. Nearly 100 vertical feet of the black, fissile Ohio Shale is visible for hundreds of feet along the stream (fig. 29). Visitors will note the well-developed joint pattern in the shale beds exposed in Lower Twin Creek. The rugged and roadless, 8,000-acre Shawnee Wilderness Area is located immediately to the east; hiking access to historic quarrying areas within the Shawnee Wilderness Area, Cabbage Patch Hollow, and Vastine Run is located approximately 3 mi to the south.

Site 15 – Village of Blue Creek, Ohio State Rte. 125 and Blue Creek Rd., Adams County

Coordinates: lat 38°46′39.0″N., long 83°19′50.9″W.
Elev. 660 ft above m.s.l.
Blue Creek 7.5-minute quadrangle

A wide pull-off is located at the southwestern corner of the junction of Ohio State Rte. 125 and Blue Creek Rd. in the village of Blue Creek. Visitors should use extreme caution as this is a very busy intersection with blind corners. This also marks the junction of Churn Creek and Blue Creek which combine to form Scioto Brush Creek, which flows northward and eastward to join the Scioto River north of Portsmouth. The northeast–southwest-trending Berea Escarpment bisects the area, creating dramatic elevation changes between sandstone-capped ridges and major drainages.

Approximately 30 ft of the Ohio Shale is exposed in a road cut at the northeast corner of State Rte. 125 and Blue Creek Rd. The dark-gray to black, highly organic-rich, fissile shale is interrupted by a geologic curiosity—large carbonate spheres known as *concretions* (fig. 30). The horizontally bedded shale bends around the concretion, both above and below. Large concretions up to 9 ft in diameter can be found in the lower portion of the Ohio Shale throughout Ohio, providing an important clue to stratigraphic position. Large concretions are typically flattened vertically (Hansen, 1994). Smaller concretions are nearly perfectly spherical, sometimes resembling cannonballs, and are normally found higher in the section of the Ohio Shale.

The cores of larger concretions usually are filled with the mineral calcite ($CaCO_3$), which may surround a fish bone or fragment of fossil wood. The core may also contain other

FIGURE 29.—Ohio Shale outcrop along Lower Twin Creek in Adams County, Ohio. Nearly 100 ft of fissile, black shale is exposed.

FIGURE 30.—Ohio Shale exposed at the intersection of State Rte. 125 and Blue Creek Rd. in Adams County, Ohio. Note the large concretion, nearly three feet across with the typical flattened, spheroidal aspect, in the center of the photo. The surveying rod is 5 ft high.

minerals, such as dolomite ($CaMg(CO_3)_2$), barite ($BaSO_4$), quartz (SiO_2), or pyrite (FeS_2). Small amounts of carbonaceous (organic-rich) matter are usually present, which results in a sulfurous odor on fresh surfaces (Carlson, 2015).

The Ohio Shale accumulated during the Late Devonian Period (approximately 360 m.y.a.) in a deep basin to the west of the rising Acadian Mountains. The Acadian Orogeny was a mountain-building event that created the ancestral Appalachian Mountains during a span of nearly 50 million years. The Acadian Mountains were thought to block the westerly trade winds, creating a rain shadow on the west side. The deep basin to the west was starved of sediment, which caused the bottom waters to slowly accumulate oxygen-deprived, highly organic-rich matter that later lithified to become the thick Ohio Shale. It was in this environment, before lithification, that the concretions are thought to have formed (Hansen, 1994).

The formation of the Ohio Shale concretions has been a subject of scientific investigations for decades. Geologists suggest that formation of the concretions began after deposition of the shale but before complete compaction. Crystallization began at a nucleus and spread outward. Most likely the concretions formed around decaying organic matter and initially may have been masses of low-density, organic matter known as *adipocere* (Criss and others, 1988). High **pH** (**alkaline**) groundwater created by the decaying matter caused carbonate to precipitate with the calcite, subsequently replacing the adipocere. Mineral replacement and secondary growth of crystals was an important aspect of concretion development. Geologists think that the low-density adipocere helped to maintain the spherical shape. Many aspects about the formation of concretions are still not well understood, particularly because nearly 90 percent of the concretions do not have a recognizable organic nucleus.

Concretions not only contain minerals but can contain fish remains. Arguably the most spectacular fossils in Ohio, huge shark-like jawed fishes called *arthrodires,* have been recovered from concretions within the Ohio Shale (Hackathorn and Feldman, 1996). These arthrodires lived in the upper portion of the seas in which the Ohio Shale was deposited; when they died, the remains sank to the quiet, muddy sea bottoms, where they were protected from currents and scavengers. The Cleveland Museum of Natural History has the world's largest collection of these fishes, with many on display (fig. 31).

FIGURE 31.—Restored skull and thoracic shield of *Dunkleosteus terrelli*. This ferocious arthrodire fish was a predator in the Devonian seas of Ohio. This speciman, which is approximately 4 ft, 7 in (1.4 meters) long, is from the Cleveland Shale Member of the Ohio Shale (Upper Devonian) in Cuyahoga County, Ohio. Photo courtesy of the Cleveland Museum of Natural History.

Site 16 – Village of Buena Vista, U.S. Rte. 52, Scioto County

Coordinates: lat 38°37′28.2″N., long 83°15′43.2″W.
Elev. 522 ft above m.s.l.
Buena Vista 7.5-minute quadrangle

The villages of Buena Vista and nearby Rockville were the center of the thriving building stone industry during the 1800s. The restored sandstone building that once housed the Buena Vista Freestone Company office (now a private residence; fig. 32) and stone walls along the Ohio River, where building stone was loaded on rafts for the Cincinnati market, are easily accessible.

The final resting place of the historically significant quarry operator, John Loughry, is located at the cemetery at Sandy Springs, 3 mi west of Buena Vista on U.S. Rte. 52. The large monument was constructed using the primary building stones quarried in the area: Berea Sandstone, Buena Vista siltstone, and sandstone from the Byer Member of the Logan Formation (fig. 33). It is interesting to compare and contrast the weathering characteristics of each building stone.

Site 17 – Long Lick Run, Township Rd. 181 and U.S. Rte. 52, Adams County

Coordinates: lat 38°39′13.0″N., long 83°20′48.1″W.
Elev. 525 ft above m.s.l.
Buena Vista 7.5-minute quadrangle

This expansive exposure of Silurian-age strata extends for nearly 1,200 ft along the north side of U.S. Rte. 52 and extends several hundred feet north along the east side of Township Rd. 181. A pull-off on Township Rd. 181, just north of U.S. Rte. 52, is large enough for at least three vehicles. As with any outcrop along a highway, extreme caution should be used when walking on the berm of the road, and it is suggested that brightly colored, reflective vests be worn by anyone accessing the outcrop. The long, straight segment of U.S. Rte. 52 allows both drivers and walkers excellent visibility, and most portions of the outcrop are more than 50 ft from the right-of-way.

Across Township Rd. 181 from the pull-off rises the most impressive Silurian outcrop within Shawnee State Forest. The Lilley Formation meets the eye first; weathering yellow orange in places, this gray to blue-gray dolomite extends upwards of 20 ft before grading into the Peebles Dolomite. The Lilley is characterized by two different dolomites which coarsen near the bottom of the formation (fig. 34). This change in grain size likely is a result of the rate of sedimentation increasing, filling the nearshore areas before extending into the sea. The Lilley is highly fossiliferous and a variety of crinoids, brachiopods, corals, and stromatoporoids can be found dispersed throughout the rock (fig. 35).

The Peebles Dolomite is easily distinguishable from the Lilley Formation because of its weathered, vuggy

FIGURE 32.—Restored stone house (private residence) on the Ohio River at Buena Vista, Ohio. The building was constructed using local building stone and was the office of the Buena Vista Freestone Company during the 1800s.

FIGURE 33.—The grave monument of John Loughry, owner of the original sandstone quarries at Rockville and Buena Vista, Ohio. The monument is located in the Sandy Springs cemetery in Adams County and was constructed using cut stone from various beds within the Buena Vista quarries. It is interesting to note the weathering characteristics of each stone block.

FIGURE 34.—Approximately 50 ft of the Peebles Dolomite and Lilley Formation are exposed north of U.S. Rte. 52 in Adams County, Ohio. Note the solution-enlarged, near-vertical joint.

FIGURE 35.—A fossiliferous zone within the Lilley Formation, north of U.S. Rte. 52 in Adams County, Ohio. Shown is a "hash" of crinoid stem fragments and corals. The coral in the center of the photo is tentatively identified as *Coenites verticillatus*. The hammer handle is 1.5 in across.

appearance. A closer look can be achieved by moving north along Township Rd. 181 and up behind a large outcrop. Here, the Peebles appears in a table-top-shaped outcrop (fig. 36). Fossils, including corals, bryozoans, cephalopods, gastropods, and bivalves, can be observed on the underside of this outcrop (fig. 37). The Silurian is often referred to as the "Age of the Corals" because of the heavy evolutionary diversification at that time; corals dominate both the Peebles Dolomite and the Lilley Formation.

Traveling east along U.S. Rte. 52, these Silurian-age rocks peek through the foliage and jut out over the highway berm. Here, overhangs are created where the less-resistant Lilley weathers away beneath the Peebles, leaving a sharp boundary between the two units. This is likely owing to a bed of shale atop the Lilley that has eroded over time and allowed more underlying rock to break away. The same explanation could be applied to the table-top feature previously described.

The Bisher Formation (fig. 9) is thin or missing at this locality. The green Estill Shale, which is near the base of the Silurian in southern Ohio (fig. 9), can be seen in the bed of Long Lick Run. Ordovician-age rocks outcrop to the west in the lower portions of Ohio Brush Creek and its tributaries.

AREAS OF GEOLOGIC INTEREST NEAR SHAWNEE

Southern Ohio abounds with sites having significant geologic features, both on private and public lands. Four of these locations were described previously—Raven Rock State Nature Preserve, Shoemaker State Nature Preserve, Davis Memorial State Nature Preserve, and Freeland's Cave (private)—with references that include more detailed information. For those who wish to explore more of the region's geology, brief summaries of a few geologically noteworthy, publicly accessible locations have been included in the following pages.

Wayne National Forest - Ironton District
6518 State Rte. 93
Pedro, OH 45659
http://www.fs.usda.gov/wayne
Lake Vesuvius Recreation Area, Lawrence County, 7 mi north of Ironton on State Rte. 93
Coordinates: lat 38°36′33.5″N., long 82°37′53.0″W.

FIGURE 36.—Outcrop of the Peebles Dolomite north of U.S. Rte. 52 in Adams County, Ohio. The "table top" exposure is the result of erosion of underlying, less-resistant units and near-vertical jointing. The surveying rod is 5 ft high.

Wayne National Forest is located in parts of eleven southern-Ohio counties and covers an area of more than 241,000 acres. The Ironton Ranger District is located in eastern Scioto, Lawrence, and western Gallia Counties. Thousands of acres of Pennsylvanian-age geology can be explored in the Ironton District, including significant natural areas such as Waterfall Cove, which features a sandstone rock house, cliffs, and a waterfall. One of the most historic areas in Ohio, from an industrial and cultural geology aspect, is part of the Ironton District of Wayne National Forest—the Hanging Rock Iron District. The first charcoal iron furnace in the district was built in 1826 in Lawrence County and used local iron ore. By the end of the Civil War, more than 45 iron furnaces were operating in southern Ohio, a very important source of iron for the production of Union armament during the conflict (Wolfe, 2012). The Ironton District has four protected sites that exhibit the huge sandstone stacks from these furnaces—Etna Furnace (1832), Pioneer Iron Furnace (1857), Cambria Furnace (1859), and the restored Vesuvius Furnace (1836). The Hanging Rock Iron District had a profound impact on the economic development of southern Ohio and northern Kentucky during the nineteenth century.

Edge of Appalachia Preserve System
4274 Waggoner Riffle Rd.
West Union, OH 45693
Cincinnati Museum Center website: **http://www.cincymuseum.org/nature**
Ohio Chapter of the Nature Conservancy website: **http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/ohio**
Visitor Hub, Adams County, 6 mi east of West Union, then 2.2 mi south on Waggoner Riffle Rd.
Coordinates: lat 38°44′55.7″N., long 83°27′49.3″W.

The Ohio Chapter of the Nature Conservancy, in partnership with the Cincinnati Museum Center, owns nearly 17,000 acres of one of the most biologically diverse areas in the Midwestern United States. The Creek Bend Overlook is an excellent place to begin your exploration of the four natural areas with dedicated trails open to the public. The preserves protect more than 100 rare plant and animal species within **xeric** limestone prairies, floodplains, cliffs, and upland forest (Platt, 1990). The preserve that best displays the geology of the region is The Wilderness Preserve.

FIGURE 37.—The tabulate coral, tentatively identified as *Favosites turbinatus*, found on the underside of the Peebles Dolomite north of U.S. Rte. 52 in Adams County, Ohio.

The Wilderness Preserve is located at lat 38°46′49.1″N., long 83°25′1.2″W. and can be reached by traveling to the small town of Lynx on State Rte. 125, then turning on Lynx Rd., which parallels State Rte. 125, to Shivener Rd. Travel north on Shivener Rd. 0.5 mi to the parking area. Outstanding outcrops of the Silurian-age Peebles Dolomite and the Lilley and Bisher Formations can be found along the hiking trail (fig. 38).

Brush Creek State Forest
http://forestry.ohiodnr.gov/brushcreek
Coordinates: lat 38°55′40.4″N., long 83°15′52.2″W.

Brush Creek State Forest covers 13,500 acres, primarily in Scioto and Adams Counties. The rugged terrain is underlain by Mississippian- and Devonian-age bedrock similar to the Shawnee area. The Stone Quarry Ridge hiking trail, located 0.5 mi west of the forest trail parking lot, accesses an old stone quarry. The village of Rarden was a quarrying center during the late nineteenth and early twentieth centuries because of its location on the Norfolk & Western Railroad, access to quality building stone nearby, and the availability of experienced quarry workers and stonecutters in the region (Bownocker, 1915).

Robert A. Whipple State Nature Preserve
194 State Rte. 247
Manchester, OH 45144
http://naturepreserves.ohiodnr.gov/whipple
Adams County, 1 mi north of U.S. Rte. 52 on State Rte. 247
Coordinates: lat 38°43′5.5″N., long 83°30′33.1″W.

The 450-acre Robert A. Whipple State Nature Preserve features sinkholes, 30- to 40-ft-high dolomite cliffs, slump blocks, and a 2-mi loop trail offering excellent views looking south toward the Ohio River along the ridge trail. The Silurian Peebles Dolomite outcrops in the area. The Peebles is characterized by very thick to massive beds of gray to blue-gray dolomite, abundant porosity, and large

FIGURE 38.—The Peebles Dolomite is exposed along the hiking trail at The Wilderness Preserve, Adams County, Ohio. The surveying rod is 5 ft high.

vugs. Below the Peebles Dolomite, the Lilley Formation is present in a few areas. The Lilley can be distinguished from the Peebles as it changes from thick to massive bedding to planar to irregular bedding of dolomitic shale with minor shale and limestone beds.

Fort Hill Earthworks and Nature Preserve
13614 Fort Hill Rd.
Hillsboro, OH 45133
http://arcofappalachia.org
Highland County, 4 mi north of Sinking Spring on State Rte. 41, 1 mi west on Fort Hill Rd.
Coordinates: lat 39°7′20.6″N., long 83°23′44.2″W.

Fort Hill Earthworks and Nature Preserve is owned by the Ohio History Connection and managed by the Arc of Appalachia Preserve System. Fort Hill covers 1,200 acres. Bedrock geology consists of the Devonian Berea Sandstone and Ohio Shale, as well as the Silurian Peebles Dolomite. **Paleokarst** within the Peebles Dolomite has been enhanced by surface erosion to form the densest collection of natural arches and a natural bridge in Ohio (Snyder, 2009). Named natural arches include Spring Creek Arch; Natural Y Arch; Sulphur Creek Gravity Arch; Boundary Arch; Baker Fork Arch; Hidden Arch; and possibly the most impressive arch in Ohio, The Keyhole. Big Cave Natural Bridge clearly shows that the Fort Hill arches formed in the upper portion of the Peebles Dolomite and that water outflows from the nearby Wisconsinan glaciation likely played a role in their formation.

Serpent Mound State Memorial
3850 State Rte. 73
Peebles, OH 45660
http://arcofappalachia.org
Adams County, 3.7 mi west of Locust Grove on State Rte. 73
Coordinates: lat 39°1′26.6″N., long 83°25′47.4″W.

Serpent Mound State Memorial has been protected by the Ohio History Connection for more than a century and is currently managed by the Arc of Appalachia Preserve System. Serpent Mound is the largest surviving prehistoric effigy mound in the world (fig. 39). The area also is part of a complex geologic terrain unique in Ohio—a meteorite

FIGURE 39.—View of the effigy mound at Serpent Mound State Memorial in Adams County, Ohio. Serpent Mound is not only the largest surviving effigy mound in the world, it is located in a complex geologic terrain related to a meteorite impact that occurred sometime between 330 and 256 m.y.a.

impact crater (Baranoski and others, 2003). The intensely faulted and folded Ordovician- to Mississippian-age sedimentary rocks encompass a roughly circular area about 5 mi across, with an outer crater rim estimated at more than 8 mi from the central uplift (Milam, 2010). Bedrock mapping, combined with core and geophysical investigations, indicate that a meteorite struck the area prior to 256 m.y.a. (Baranoski and others, 2003).

SUMMARY

Southern Ohio is a geologic treasure awaiting discovery. Exploration of the hidden wonders of this scenic, ecologically diverse, rugged but accessible area will reward the adventurous visitor with its natural beauty and historical significance. Shawnee State Park and State Forest provide nearly 100 mi^2 of public land for outdoor recreation, including geologic investigation. The region's geology can be accessed from paved roads, gravel forest roads, bridle trails, and challenging hiking trails. The ridge-top vistas are tremendous and the solitude can be invigorating. The continuing influence of the early quarry industry and the CCC are found throughout the Shawnee area. Make time to understand the natural world; it will enrich your life.

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GLOSSARY

adsorb – to collect on the surface in a condensed layer
alkaline – characterized by low acidity; also called "basic"
alluvium – loose sediment recently deposited by rivers and related floods
ashlar – thin, dressed, square-cut building stone used for wall facing
bioherm – mound of reef-like carbonate rock built by marine organisms such as corals
calcareous – containing calcium carbonate or calcite
carbonaceous – containing or rich in carbon
clastic – comprised of fragments of older, pre-existing rocks
colluvium – rock fragments and other **detritus** that collect at the bottom of slopes and cliffs
conglomeratic – containing large (>2 mm) rounded clasts with the in-between space filled with finer-grained material or chemical cement
detritus – loose rock fragments and debris from eroded and weathered rocks
diagenesis – chemical and physical changes that occur to sediment after deposition, but before it has formed rock
escarpment – long, continuous, steep slope formed by erosion that makes up the face of a plateau or ridge
fissile – splits easily along natural planes of cleavage
float – rock material that is no longer connected to an outcrop; frequently found loose and out of place at the base of a rock exposure
fossiliferous – containing fossils
glauconite – silicate mineral from the mica group that contains iron and potassium; characterized by its blue-green color; it forms through the alteration of sedimentary deposits
gradational contact – gradual change in deposition from one geologic unit into another
ichnofossils – the preserved record of biologic activity in sedimentary rock that does not necessarily contain the preserved or fossilized body parts of the organism; a term used interchangeably with the term *trace fossil*
interbedded – occurring between rock beds or existing parallel to other beds of a different material
lacustrine – relating to or forming in lakes
lithologic – referring to the physical properties of rock
members – sub-unit or interval of a geologic formation that exhibits very similar lithologic properties, even more than that of the formation as a whole
mesophytic – land plants adapted to moderate water and temperature conditions
metamorphism – the process through which metamorphic rocks are formed by heat, pressure, and chemical alteration; impacts include changes in rock structure, mineralogy, and texture
organic-rich – containing a significant amount of organic carbon and often black in color; common organic-rich rocks include coal and black shale
paleoenvironmental – related to the environmental conditions during a past geologic time period
paleokarst – an area of ancient karst, or rock dissolution, that has been preserved; commonly filled with lithified sediments
petroliferous – yielding or containing petroleum
pH – acidity or alkalinity of water or another solution measured on a scale from 1 (highly acidic) to 14 (highly alkaline)
pluvial – formed from or related to rainfall
soft-sediment deformation – process where unsolidified sediment is folded, warped, or otherwise reformed because of water or air currents or possibly dewatering; occurs during or shortly after deposition
stratigraphic – related to the correlation, distribution, and description of rock layers
subduction zone – an area where two tectonic plates come together and one is forced under the other; responsible for earthquakes, volcanism, and mountain building events
thrust fault – a low-angle fault where the ground on one side moves upward and on top of the other side
turbid – dark, muddy conditions resulting from high amounts of sediment or other particles being suspended
unconformity – a surface, in a sequence of sedimentary rocks, where deposition was not continuous and erosion may have occurred
vitrified – transformed by heat into a glasslike material
vugs – cavities in rocks, formed by fracturing or dissolution, that often contain crystals of precipitated minerals
xeric – being extremely dry or devoid of moisture

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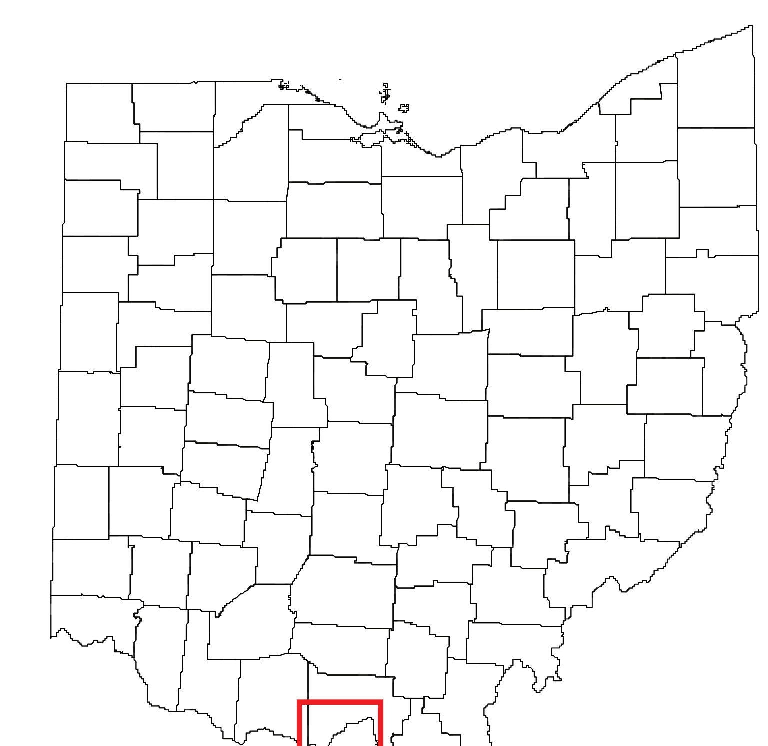
PLATE 1

Geologic map and cross section of the Shawnee State Park and State Forest region with field trip sites indicated.

FIELD TRIP SITES

1. Shawnee State Park Lodge and Conference Center
2. Shawnee State Park Lodge Road
3. Ohio Route 125 near Turkey Creek Lake Dam
4. Roosevelt Lake
5. Picnic Point
6. Shawnee State Park Marina and Golf Course
7. Alum Rock
8. Copperhead Fire Tower
9. Shawnee State Forest Road 6
10. McBride Lake
11. Shawnee State Forest Road 5 road cut, overlook, and Grass Lick Bridle Trail
12. Upper Twin Creek
13. Churn Creek
14. Lower Twin Creek
15. Village of Blue Creek
16. Village of Buena Vista
17. Long Lick Run



Location of the Shawnee State Park and State Forest region

GIS Cartography by Dean R. Martin

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