JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
VOLUME 50, NUMBER 1, JANUARY 1975

LOWER PENNSYLVANIAN STRATA OF THE NORTHERN PART OF SAND MOUNTAIN, ALABAMA, GEORGIA, AND TENNESSEE

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ABSTRACT

Detailed mapping of about 135 square miles of the northern end of Sand Mountain has shown that the previous correlations of these two units as Warren Point Sandstone and Sewanee Conglomerate is incorrect. The upper one is indeed the Warren Point, but the lower one correlates with a lower Sandstone member in the Raccoon Mountain Formation. In the area mapped the Raccoon Mountain Formation is divided into two new members, the Flat Rock and Norwood Cove. It was found that there is no evidence of an erosional contact between Pennsylvanian and the underlying Mississippi rocks. The boundary is determined arbitrarily on the basis of certain lithologic characteristics.

INTRODUCTION

The coal-bearing rocks on Sand Mountain have been studied since the mid 1800's. Over the years there have been many attempts to correlate cliff-forming sandstones in Alabama with those in adjacent parts of Tennessee and Georgia. The stratigraphic subdivisions of Lower Pennsylvanian strata on Sand Mountain are reviewed herein. Nomenclatural revisions and new correlations also are suggested. The problem of the Mississippian-Pennsylvanian boundary is discussed.

GEOGRAPHIC SETTING

Sand Mountain is located in the northeastern corner of Alabama, and lies between Browns Valley to the northwest and Wills Valley on the southeast. As a gently rolling upland Sand Mountain has elevations ranging from 1,400 to 1,500 feet above sea level. Exposed on its top surface are rocks of Pennsylvanian age. Its margin is marked by steep escarpments that separate it from the lowlands nearly 1,000 feet below. Massive sandstone cliffs form a nearly continuous wall along the edges of Sand Mountain. The only indentations in these cliffs occur along the northwestern edges where several streams have eroded deep valleys into the upland surface. A continuation of the surface of Sand Mountain northward into Tennessee is called Walden Ridge. These two topographic features are separated by the gorge of the Tennessee River where it flows westward from the Valley and Ridge province into Sequatchie Valley (Fig. 1).

Only the northern portion of Sand Mountain, an area of approximately 135 square miles, is considered in this study. This area includes parts of Jackson and DeKalb Counties, Alabama; Dade County, Georgia; and Marion County, Tennessee.

Both Sand Mountain and Lookout Mountain are broad synclinal features, whereas the intervening valleys are anticlinal. The synclinal axis of Sand Mountain lies near the center of the mountain roughly parallel to the general topographic trend. Because of this the elevations along the escarpment are slightly higher than those of the interior portions.

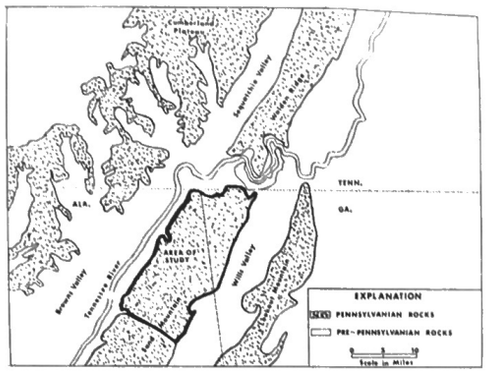

FIG. 1: *Northern part of Sand Mountain in relation to surrounding topographic features.*

PREVIOUS WORK

Safford (1869, p. 382-384) was the first to describe the geology of this area when he measured the section at the Etna mine in Marion County, Tennessee on the south side of Raccoon Mountain. Safford divided the coal measures into Upper Measures and Lower Measures. Separating these units were two conglomerates which he named Lower Conglomerate and Upper Conglomerate. An unnamed unit separated the two conglomerate beds (Table 1). At the Etna mine the Upper Conglomerate is 75 feet thick; 130 to 170 feet beneath it is the 70 to 100 foot-thick Lower Conglomerate. Safford indicated that "at some points the two rocks appear to come together and form a single stratum". He named the Lower Conglomerate the Cliff Rock, and he later called the Upper Conglomerate the Sewanee (1893, p. 89).

Hayes (1892) made the first geologic study of the Sand Mountain area in Alabama and adjacent parts of Georgia. He divided the Coal Measures into Lookout Sandstone below and Walden Sandstone above. The contact between these two formations was placed at the top of a conglomerate which has an average thickness of 40 feet. The Stevenson folio (Hayes, 1895) covers essentially the same areas as did the earlier Alabama Survey Bulletin (Hayes, 1892).

McCallie (1904) published a preliminary report on the coal deposits of Northwest Georgia. He concluded that the Lookout Sandstone, described by Hayes (1899), would correlate with Safford's (1869) Lower Measures if the Lower Conglomerate were included.

From his work in the Southern Tennessee coal fields, Nelson (1925, p. 39) revised Safford's nomenclature. Nelson divided the coal measures into six formations. His main contribution was the recognition that the Pennington Formation, which had been included in the Lower Measures by Safford (1869), is actually of Mississippian age.

The stratigraphic classification proposed by Nelson was not

TABLE 1: *Summary of Pennsylvanian nomenclature on Sand Mountain.*

	NORTHEAST ALABAMA	NORTHWEST GEORGIA				TENN. ALA., GA.	SOUTHERN TENNESSEE		
	HAYES (1892)	BUTTS (1946)	CULBERSON (1942)	MOORE (1944)	STEARNS & MITCHUM (1962)	THIS STUDY	WILSON et al (1956)	NELSON (1925)	SAFFORD (1869)
PENNSYLVANIAN SYSTEM	UNITS MISSING	UNITS MISSING	UNIT MISSING	UNITS MISSING	UNITS MISSING	UNITS MISSING	CRAB ORCHARD MTNS. GROUP: NEWTON SANDSTONE / WHITWELL SHALE	NEWTON SANDSTONE / WHITWELL SHALE	UPPER MEASURES
	WALDEN SANDSTONE	POTTSVILLE FORMATION	CRAB ORCHARD MOUNTAINS FORMATION: VANDEVER MEMBER / NEWTON MEMBER / WHITWELL MEMBER / SEWANEE MEMBER	WALDEN FORMATION / UPPER CONGLOMERATE	POTTSVILLE SERIES / NEW RIVER GROUP: UNNAMED UNITS	SEWANEE CONGLOMERATE	SEWANEE CONG.	SEWANEE CONGLOMERATE	UPPER CONGLOMERATE
						SIGNAL POINT SHALE	SIGNAL POINT SHALE	UNNAMED UNIT	UNNAMED UNIT
						WARREN POINT SANDSTONE	WARREN POINT SANDSTONE	WARREN POINT SANDSTONE	LOWER CONGLOMERATE
	LOOKOUT SANDSTONE		GIZZARD FORMATION: SIGNAL POINT MEMBER / WARREN POINT MEMBER / RACCOON MOUNTAIN MEMBER	LOOKOUT FORMATION: UNNAMED UNIT / LOWER CONGLOMERATE / UNNAMED UNIT	LOOKOUT SANDSTONE	RACCOON MOUNTAIN FORMATION: FLAT ROCK MEM. (UPPER SHALE UNIT / LOWER SANDSTONE UNIT); NORWOOD COVE MEMBER	GIZZARD GROUP: RACCOON MOUNTAIN FORMATION	LEE GROUP, GIZZARD FORMATION: UNNAMED UNIT	LOWER MEASURES

adopted by geologist working subsequently in Georgia. Sullivan (1942, p. 30-32) placed all of the Pennsylvanian rocks on Sand and Lookout Mountains in northwest Georgia in the Pottsville Formation. A similar procedure was followed by Butts (1946) in his geologic map of Northwest Georgia (Table 1).

Since the investigation by Hayes (1892), it has been customary to divide Pennsylvanian rocks in the vicinity of Sand Mountain into two main units. Through the years the names have changed, but essentially the same two units are involved. Hayes indicated also that there are two major beds of conglomerate. One is near the base of the Walden Sandstone; the other is at the top of the underlying Lookout Sandstone. The only major departure from this trend was by Sullivan (1942) who labeled all the rocks on Sand and Lookout Mountains above the Pennington Formation as Pottsville.

The Pennsylvanian Subcommittee of the National Research Council Committee on Stratigraphy (Moore, Chm., 1944) returned to the twofold classification of Pennsylvanian strata for Northwest Georgia. These correlations were prepared by Wanless from reports by McCallie (1904) and from his own field observations. He divided the rocks into Lookout Formation and Walden Formation (Table 1).

Wanless (1946, p. 8) later made a reconnaissance study of the entire Southern Appalachian Coal field, and his descriptions of the rock units in Northern Georgia and Alabama are similar to the sequence described by Nelson (1925) for Tennessee. Johnson (1946) prepared a preliminary geologic map of the coal deposits on Sand and Lookout Mountains in Dade and Walker Counties, Georgia for the U.S. Geological Survey. Much of the information was based on a core-drilling program sponsored by the U.S. Bureau of Mines and Georgia Power Company. The stratigraphic nomenclature of Johnson was composite from Hayes (1892) and Nelson (1925). Wilson, Jewell, and Luther (1956) expanded the terminology for Pennsylvanian rocks in Tennessee. Through reconnaissance mapping, supplemented by detailed studies of key areas, they were able to correct some of the previous misconceptions of Nelson (1925) and Wanless (1946).

The first regional study was made by Stearns and Mitchum in 1957. The results of their investigation appeared in Branson (1962). They divided the Pottsville series into three groups which are (ascending) Pocohontas, New River, and Kanawah. All of the strata in Southern Tennessee and Northwestern Georgia were assigned to the New River Group. In general Stearns and Mitchum followed the correlations made by McCalley (1891).

Culbertson (1962), following a reconnaissance trip to Sand, Lookout, and Raccoon Mountains, and after a study of previous reports and air photographs used by Johnson (1946), reported a stratigraphic sequence which was nearly identical to that for Tennessee by Wilson, Jewell, and Luther (1956). However, the latter authors used two groups containing six formations, whereas Culbertson lowered the status of the two groups to formations and the formations to members.

A coal resource study by Shotts and Riley (1966) used the terms Upper and Lower Conglomerate as defined by Safford (1969). Ferm and others (1972) used essentially the same nomenclature as was proposed by Wilson and others (1956); however, in their correlations Ferm and others indicated that the Upper Conglomerate should be correlated with the Sewanee Conglomerate, and that the Lower Conglomerate should be correlated with the Warren Point Sandstone.

STRATIGRAPHY

The Pennsylvanian strata on Sand Mountain are an erosional remnant of formerly more extensive coal-bearing rocks which covered a large part of the Eastern United States. Underlying Sand Mountain are rocks of Early Pennsylvanian (Pottsville) age composed largely of quartzose sandstones, siltstones, clay shales, and coals. In this study the Pennsylvanian rocks have been subdivided into four formational units which are (ascending) Raccoon Mountain Formation, Warren Point Sandstone, Signal Point Shale, and Sewanee Conglomerate.

RACCOON MOUNTAIN FORMATION

The type section for the Raccoon Mountain Formation is located at Scratch Ankle Hollow (Wilson *et al.*, 1956, p. 1). Here the Raccoon Mountain Formation consists of 353 feet of sandstone, shale, and coal. Later work by the Tennessee Division of Geology resulted in a revision of the basal contact upward so that the thickness of the unit as presently defined is 268 feet at the type locality. The sandstones are neither massive nor conglomeratic, and the formation cannot be easily subdivided. But, as these beds are traced southward into Alabama, a sandstone zone in the upper part of the Raccoon Mountain Formation thickens and becomes the massive, cliff-forming, lower sandstone of the Flat Rock Member (i.e., The Lower Conglomerate of earlier workers in Georgia). In the area of study the Raccoon Mountain Formation ranges from 243 to 252 feet thick (Fig. 2).

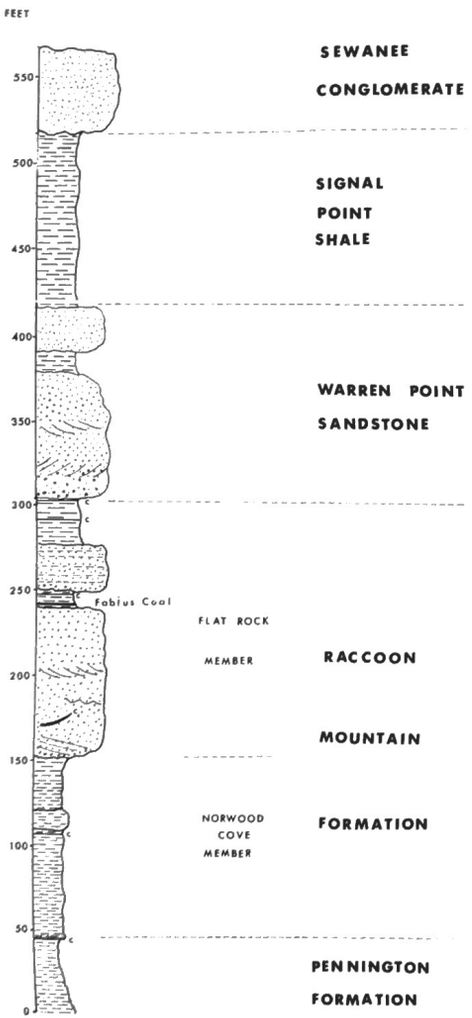

FIG. 2: *Generalized stratigrophic section of Sand Mountain.*

Norwood Cove Member. The Norwood Cove Member is here named for exposures in Norwood Cove along Alabama State Highway 117 on the western side of Sand Mountain. This member consists of a sequence of dark-gray shale containing numerous siderite nodules, dark-gray, thin-bedded siltstones, and gray, thin-bedded, medium to fine-grained sandstone. The siderite nodules are flat or disc-shaped, range from 5 to 7 inches in diameter, and are aligned parallel to the bedding. Interbedded with the shales are lenses of fine-grained sandstone up to one half inch thick. Some of the siltstone beds are composed largely of laminae 0.025-0.2 mm in thickness. In most instances the thinner layers contain a larger amount of carbonaceous material.

Ripple marks can be seen on the undersides of many overhanging siltstone ledges. These ripples are current-type with a wave length of about three inches and an amplitude of one-fourth of an inch. In general the current direction indicated by these ripples is southwest.

The thickness of the Norwood Cove Member at the type locality is 105 feet. The average thickness of this member as mapped on Sand Mountain is about 100 feet. However, in Marion County, Tennessee along the northern edge of Sand Mountain the Norwood Cove attains a maximum thickness of nearly 200 feet.

The basal contact of the Norwood Cove Member is gradational with the underlying Pennington Formation, while the upper contact is unconformable with the overlying Flat Rock Member. The transitional nature of this unit is indicated by the fact that fossils from siderite nodules near the base are of Chesterian age while spores recovered from coals in the upper part indicate an early Pennsylvanian age.

Type section of the Norwood Cove Member:
Secs. 25 and 26, T.2S., R.8E.

Flat Rock Member:	*Thickness Feet*
Lower Sandstone unit (lower part)	
Sandstone, very light gray, medium-grained containing thin conglomeratic zones, bedding medium to massive, stylolite seams, cross-bedded; coal seam (0-11 inches thick) occurs 30 feet above the base, base uneven	42+
Norwood Cove Member (105 feet)	
Shale, dark gray, silty, evenly-bedded, thin (3-10 inches) coal 10 feet below top; small siderite concretions aligned parallel to bedding	18
Sandstone, dark gray to gray, medium- to fine-grained, thin-bedded; roll structures near base	18
Coal, thin, 6-14 inches, distinct zone of seat earth beneath seam	2
Shale, gray, silty, evenly-bedded, contains scattered siderite nodules	17
Siltstone, dark gray, thin-bedded, contains carbonaceous fragments; base sharp	9
Shale, dark gray, containing greenish-gray calcareous zones near top; contains siderite nodules which contain marine mollusks of Chesterian age	30
Shale, very dark gray, silty, sandstone lens at base ranging in thickness from 2-15 inches	10
Coal, thin, thickness ranges 2-15 inches	1
(Measured Section) Total	147

Flat Rock Member. The Flat Rock Member consists of sandstone and shale that unconformably overlies the Norwood Cove Member. It is here named for exposures located near the town of Flat Rock in Jackson County, Alabama. The Flat Rock Member can be divided into a lower, massive, conglomerate sandstone unit and an upper gray shale unit. The type section is located along Alabama State Highway 117 just north of Norwood Cove, about six miles northwest of the Town of Flat Rock.

Complete sections are found in Norwood Cove and Scratch Ankle Hollow in Marion County, Tennessee. The thickness of the Flat Rock Member in the type area is 150 feet; it gradually thins northward and on the northern end of Sand Mountain it is 125 feet thick. In the vicinity of Kings Bend, near the southern margin of the area, the thickness reaches 200 feet. This member forms about 70 percent of the upper surface of Sand Mountain. The lower part of the member forms prominent cliffs along the margins of the mountain. The base of this member is marked by 100-foot thick, cliff-forming conglomeratic sandstones. The shale beds of the Flat Rock Member are gray to brown in color whereas the underlying shales of the Norwood Cove Member are typically dark gray and contain numerous disc-shaped siderite nodules.

The upper boundary of the Flat Rock Member is placed at the undulatory base of the massive, generally cliff-forming, sandstones of the overlying Warren Point Sandstone. The lower contact is placed at the base of the lowest major cliff-forming sandstone above the shales of the Norwood Cove Member. The type section of the Flat Rock Member is described below:

Type Section of the Flat Rock Member:
N.W.1/4, Sec. 25, T.2S., R.8E.

Warren Point Formation (lower part)	*Thickness Feet*
Sandstone, brown to gray, medium-grained, iron-stained, crossbedded, deeply weathered friable	44+
Raccoon Mountain Formation	
Flat Rock Member	
Upper Shale Unit	
Shale, gray, weathers brownish-gray, forms topographic bench	45
Lower Sandstone Unit	
Sandstone, light gray, conglomeratic, massive-bedded, very friable; thin lens of clay shale at base; contact with the overlying shale is gradational	18-22
Sandstone, light gray, medium- to massive-bedded, thin coal stringers near top, profusely jointed; contains cross-bedded thin conglomeratic zones and stylolite seams; discontinuous coal seam (0-11 inches) occurs 30 feet above the base; basal contact undulatory	75-80
(Flat Rock Member) Total	138-147
Norwood Cove Member upper part)	
Shale, dark gray, silty, evenly-bedded	10+
(Measured Section) Total	193-202

The Fabius coal, which occurs just above the Lower Sandstone unit, has been mapped in two areas. One area is located adjacent to Rocky Branch and Warren Smith Hill southeast of Fabius, Jackson County, Alabama. A second area is west of Whiteoak Gap along Big Spring Branch, Dade County, Georgia. Recent core drilling has indicated that mineable thicknesses of the Fabius coal are present on both sides of Flat Rock Creek at an elevation of about 1,340 feet.

The lower part of the Flat Rock Member consists of a light-gray, massive- to medium-bedded sandstone. Throughout this sandstone unit there are zones of quartz pebbles ranging in size from 10 to 25 mm. It has an average thickness of about 100 feet, and typically forms vertical cliff-like ramparts around the edge of Sand Mountain. The lowermost beds contain zones of conglomeratic whereas the upper beds consist of a medium-bedded, medium-grained sandstone.

The upper part of the Flat Rock Member is a grayish-brown clay shale that ranges in thickness from 25 to 60 feet. It contains scattered thin beds of sandstone. On Warren Smith Hill where 25 feet of it is exposed, it contains two small coal seams 6 inches and 12 inches thick. The upper contact of the shale is unconformable with the overlying Warren Point Sandstone. The lower contact on the other hand is gradational with the lower sandstone.

WARREN POINT SANDSTONE

The Warren Point Sandstone was named by Nelson (1925, p. 43) for exposures one-half mile north of Monteagle, Tennessee. In Tennessee the Warren Point ranges up to 200 feet in thickness (Wilson *et al.*, p. 4) and forms prominent escarpments along the edge of the Cumberland Plateau. Safford (1869, p. 382) referred to this massive sandstone as the Cliff Rock Sandstone.

Along the northern edge of San Mountain the Warren Point Sandstone makes an upper cliff-forming bed which many earlier workers misidentified as the Sewanee Conglomerate. The formation overlies the Flat Rock Formation, and the contact is placed at the base of a massive, but commonly friable lower sandstone.

The Warren Point is about 125 feet thick on Sand Mountain, and is composed of two sandstone zones separated by a thin clay shale. Typically the lower part of the formation is conglomeratic, and where well cemented it forms massive cliffs, such as located at Kosh Bluff (Sec. 7, T.3S., R.9E) and at Floral Crest (Sec. 9, T.2S., R.10E.). Where exposed the base of the sandstone unconformably overlies the shales in the Flat Rock Member of the Raccoon Mountain Formation.

The upper half of the Warren Point is a brown, medium- to fine-grained, medium-bedded sandstone. Upon weathering it develops a pinkish cast. Between the upper and lower sandstone zones is about 20 feet of yellowish-gray shale.

SIGNAL POINT SHALE

Overlying the Warren Point Sandstone is a series of shale beds called the Signal Point Shale. This formation takes its name from Signal Point, which is located just south of the town of Signal Mountain in Hamilton County, Tennessee (Wilson *et al.*, 1956, p. 4). Exposures of the Signal Point Shale on Sand Mountain are confined to a small area between Nickajack Cove and Murphy Hollow in the extreme northern section. Here the rocks are typically light brown, evenly bedded, clay shale, 100 to 150 feet thick. The upper part is rarely exposed, and occurs only near the Georgia-Tennessee State boundary, at elevations above 1600 feet.

SEWANEE CONGLOMERATE

Safford (1893, p. 72) named the Sewanee Conglomerate for exposures at the town of Sewanee in Franklin County, Tennessee. He described the formation as being a heavy-bedded sandstone abounding in white quartz pebbles. In the area under investigation, quartz pebbles, which are characteristic of the Sewanee elsewhere, were not found.

On Sand Mountain the Sewanee has a maximum thickness of 40 to 50 feet and consists of light-brown, fine-grained, medium-bedded sandstone. The Sewanee Conglomerate is the youngest formation mapped in the area of study and is preserved only in the northern portion as outliers at the higher elevations.

PENNSYLVANIAN-MISSISSIPPIAN BOUNDARY

On Sand Mountain the position of the boundary between Mississippian and Pennsylvanian rocks is difficult to determine with any degree of assurrance. There is no evidence of large-scale erosion at the contact; rather, the beds appear to be entirely gradational. The transition from sandy, light brown to gray shales of the Pennsylvanian System to the maroon, brown, and greenish-gray shales of the underlying Mississippian Pennington Formation can be detected in the field only in a few selected localities. Ideal sites for observation of the systemic boundary are commonly found along highway road cuts. In areas where the exposures are poor, the top of the Mississippian is placed arbitrarily at the highest appearance of maroon and green shales. In Parbon Gulf a 10-foot zone of knobby limestone marks the top of the Mississippian and immediately beneath the limestone are 70 feet of interbedded greenish-gray shale and fine-grained sandstone. Below this sequence are typical Pennington lithologies, including thin limestone interbedded with maroon and green shales. The presence of this somewhat Pennsylvanian-type sandstone near the upper part of the Pennington Formation could easily result in the base of the Pennsylvanian being placed too low in the section.

Over much of the western Cumberland Plateau in Tennessee and Kentucky (Bergenback and Wilson, 1961) there are clear lithologic criteria for locating the Pennsylvanian-Mississippian

boundary. However, England and Smith (1960) reported that in the vicinity of Cumberland the Pennington is in a transitional relationship with the overlying rocks of the Pennsylvanian. They concluded that the contact between the two formations represents a transition, where the beds of Lee grade laterally into, and intertongues with, beds of upper Pennington age.

Along Alabama State Highway 117 the beds above and below the contact are parallel, and a thin, two- to three-inch coal appears just beneath the lower-most sandstones and shales assigned to the Pennsylvanian. L. R. Wilson (pers. comm., May 1967) of the Oklahoma Geological Survey stated that spores taken from this coal have definite Chesterian affinities. A group of marine invertebrates collected from a zone of siderite nodules approximately 40 feet above this coal has been identified as Chesterian.

Thus it appears that the assignment of the Pennsylvanian-Mississippian boundary on Sand Mountain based on arbitrary lithologic characteristics is functional only for large scale mapping. The absence of adequate faunal occurrences makes this task very difficult in a given exposure.

There are several lithologies in the Norwood Cove Member which are typically Pennsylvanian. This is also true of the underlying Pennington rocks. Selected criteria for distinguishing these two units are listed below:

Rock Types	*Other Features*
PENNSYLVANIAN	
(Norwood Cove Member)	Plant fossils abundant in shales. Quartz pebbles in massive sandstones. Carbonaceous fragments and micaceous grains in sandstones, marine fossils rare.
Sandstone: light-brown, massive, locally conglomeratic.	
Shale: brown to dark-gray, silty to sandy. Coal beds usually 6 inches or more in thickness.	
MISSISSIPPIAN	
(Pennington Formation)	Marine fossils common; medium to thin-bedded sandstone. Shales often calcareous. Sandstone characterized by greenish-gray mica flakes.
Sandstone: light-brown to greenish gray; medium- to fine-grained, rarely massive.	
Shale: maroon to greenish-gray commonly dark-gray.	
Coal: thin, rare.	
Limestone: silty, medium-gray.	

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