LOWER PENNSYLVANIAN-UPPER MISSISSIPPIAN DEPOSYSTEMS, MONTEAGLE MOUNTAIN, TENNESSEE

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ABSTRACT—Three roadcut exposures of Carboniferous (Upper Mississippian-Lower Pennsylvanian) rocks along westbound and eastbound lanes of Interstate 24 on Monteagle Mountain in eastern Tennessee are described. The Upper Mississippian Pennington Formation tidal flat complex contains red, green, and black shales along with thin-bedded, near-shore carbonates as well as orthoquartzitic offshore bars. With localized exceptions, the Mississippian-Pennsylvanian systemic contact is transitional. Marginal marine accumulations characterize the lowermost Pennsylvanian Raccoon Mountain Formation. The Pennsylvanian Warren Point Sandstone, Signal Point Shale, and Sewanee Sandstone formations were deposited as braided stream complexes made of partial to complete cycles of sedimentary structures ranging from in-channel basal scours, trough crossbeds, and cross channel bars through rippled sandflats to vertical accumulations of siltstone and shale.

In the spring of 1972, Ferm et al. (1972) led a field trip to Monteagle Mountain, located on the western rim of the Cumberland Plateau in northwestern Marion and southeastern Grundy counties in southeastern Tennessee (Figs. 1 and 2). This field trip was part of a Carboniferous symposium associated with a Southeastern Section Meeting of the Geological Society of America held in Tuscaloosa, Alabama. On part of this trip, Garrett Briggs and James Eason described roadcuts on eastbound and westbound lanes of Interstate 24 on the east and west sides of Monteagle Mountain, respectively. These workers considered Carboniferous rocks located at this area to have formed in marginal marine tidal flat and tidal delta paleoenvironments.

Later, Moore and Briggs (1978) published a geologic map of the Monteagle Quadrangle in Tennessee. They mapped Mississippian formations ranging from the St. Louis Limestone through the Pennington Formation and the Pennsylvanian from the Raccoon Mountain Formation through the Whitwell Shale. In a regional sense, rocks of the Pennsylvanian System on the Cumberland Plateau are considered to have prograded over the Mississippian System with the regional direction of sediment transport located in the southwestern quadrant of the compass.

In 1989, the eastbound lane of Interstate 24 on the east side of Monteagle Mountain was re-excavated to alleviate driving hazards. Schematic diagrams of rock exposures have been prepared from extensive Polaroid filmstrips.

DESCRIPTION OF ROADCUT EXPOSURES

Monteagle Mountain Roadcut, Westbound Lane, Interstate 24, Upper Mississippian and Lower Pennsylvanian System--The rock record exposed in roadcuts along the westbound lane of Interstate 24 on the east side of Monteagle Mountain contains Upper Mississippian and Lower Pennsylvanian sedimentary rocks (Fig. 3). In this area, the Upper Mississippian Pennington Formation is composed of red, green, and dark gray (siderite-bearing) shales interbedded with scour-filling dolomicrite and thin- to thick-bedded fragmental carbonates. Figure 3 shows the Pennington to be in transitional contact with the overlying lowermost Pennsylvanian Raccoon Mountain Formation.

At this site, the Raccoon Mountain contains quartz arenite bodies, surrounded by dark gray shale. One of these sandstone bodies has a mound-like shape and rests sharply on Pennington limestone. This may be considered as a very local unconformable contact, but eastward of the sandstone mound are thin beds of fossiliferous green and red shale plus 0.61 m of red limestone (fossil fragmental), all of which grade upward into coalbearing, dark gray shale. This situation learly represents a transitional systemic boundary. At the top of the Raccoon Mountain, there is 0.30-m thick coal, underlain by rooted seatearth.

Overlying Pennsylvanian deposits are composed of four-plus (cycles 1 to 5), fining-upward sequences composed largely of quartz arenite sandstone that have been assigned to the Warren Point Sandstone, Signal Point Shale, and Sewanee Sandstone stratigraphic units. Cycle 1 shows shallow scours filled with structureless sand at the base that are overlain by thin-bedded, rippled sandstone which are, in turn, overlain by thin-bedded dark gray shale. Cycle 2 is a repeat of cycle 1. Cycle 3 shows shallow scours at its base (infilled with structureless sandstone). These give way vertically to medium- to large-scale trough crossbeds and medium- to large-scale foresets (planar tabular crossbeds). Cycle 3 is capped by thin-bedded, rippled, shaly siltstone layers. All of cylces 1 and 2 plus scours and troughs of cycle 3 are mapped as Warren Point Sandstone. Thin-bedded, rippled silty units at the top of cycle 3 mark the Signal Point Shale. Cycle 4 is similar to cycle 3 in that scours at the base are overlain by medium- to large-scale troughs and foresets. However, cycle 5 which is totally made up of scours (upper part of cycle 5 has been eroded) has eroded most of the shaly or silty thin-bedded, rippled units of cycle 4. Note that 5.08- to 7.62-cm thick coals partially infill certain scours in cycle 5. All of cycles 4 and 5 are mapped as Sewanee Sandstone.

Eastbound Lane of Interstate 24, East Side of Monteagle Mountain--Carboniferous rocks of the Upper Mississippian Pennington Formation, Lower Pennsylvanian Raccoon Mountain Formation, and Warren Point Sandstone are exposed in roadcuts along the eastbound lane of

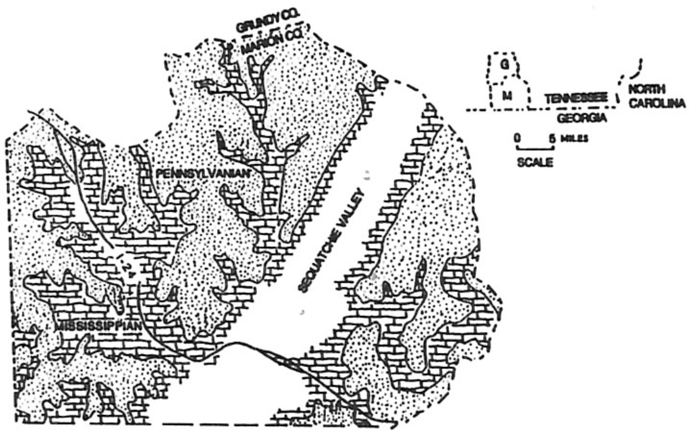

FIG. 1. Location of Interstate 24 in Marion and Grundy counties, Tennessee, and generalized surface expression of carboniferous rocks.

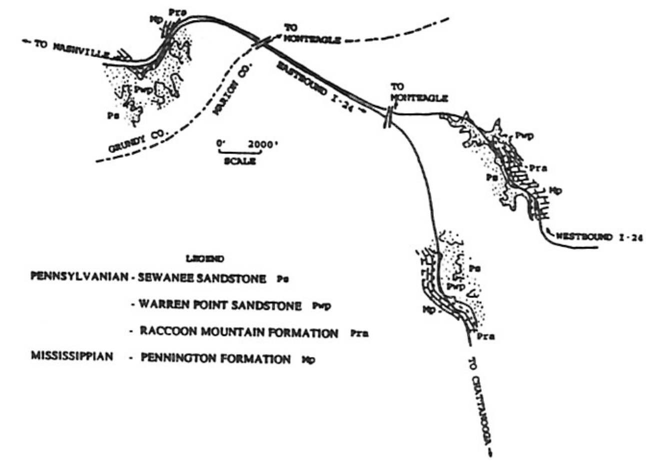

FIG. 2. From geologic map of Monteagle quadrangle.

Interstate 24 on the east side of Monteagle Mountain (Fig. 4). In these exposures, the Pennington is composed of red and green shales as well as thin-bedded, fragmental limestones and scour-filling dolomicrites.

At the top of the Pennington, there is a unique, white, quartz-rich sandstone body (orthoquartzite) that displays a scoured base filled with massive, structureless, coarse sand that contains what appear to be granule-sized, re-maroon siderite clasts. This orthoquartzite unit "fines upward" with small-scale, rippled layers of fine-grained, largely angular quartz sand with a kaolinitic clay paste binder at the top. Thin-section study shows that the coarser-grained, rounded quartz grains form a scour fill at the base that is largely cemented with anderite (an iron-bearing dolomite). Thus, the so-called siderite clasts are actually diagenetic growths of ankerite crystals that have occluded several quartz grains.

Placement of the Mississippian-Pennsylvanian systemic boundary here is largely dependent on the bias of the observer. If one chooses to mark the boundary at the base of the orthoquartzite, then the systemic boundary is unconformable. However, if the boundary is placed at the top of the orthoquartzite, then the contact may be viewed as transitional. I have chosen to place the contact at the top of the orthoquartzite.

The Pennsylvanian Raccoon Mountain Formation is considered as a fining-upward sequence (siltstone to shale). A 0.9- to 1.2-m thick deposit of dark gray siltstone conformably overlies the orthoquartzite. A 15- to 20-cm thick coal seam overlies this siltstone unit. Laterally, the upper surface of the 0.9- to 1.2-m thick siltstone has been scoured to a depth of 1.2 m and infilled with dark gray siltstone. The coal seam also has been eroded by the scouring process. Beneath the siltstone units, there is a 1.2- to 1.8-m thick, dark gray shale unit. Dark gray shale makes up the upper part of the Raccoon Mountain.

Thin-bedded, rippled, quartz arenite siliciclastics make up the basal part of the Warren Point Sandstone (cycle 1). It is important to note that the diagram of this roadcut shows these Warren Point, thin-bedded, rippled units in sharp contact with the underlying Raccoon Mountain shale. Actually, the sandstones grade laterally, in a westerly direction, into the dark gray shale. Large-scale scour structures overlie these basal rippled units in unconformable contact (cycle 2). Here, the upper surface of the Warren Point is erosional.

Eastbound Lane of Interstate 24, West Side of Monteagle Mountain--Carboniferous rocks exposed in this roadcut are mapped as Upper Mississippian Pennington Formation, Lower Pennsylvanian Raccoon Mountain Formation, and Warren Point Sandstone (Fig. 5). At the base of this roadcut is a white, massive, structureless orthoquartzite sandstone unit with interstitial kaolin. This unit is interbedded with green shale near its base and is assigned to the Pennington Formation. Further, it is considered to be correlative with the orthoquartzite deposit described from the roadcut beside eastbound Interstate 24 on the east side of Monteagle Mountain. A portion of the upper surface of this orthoquartzite unit has been scoured and infilled with quartz arenite sandstone. Both the orthoquartzite unit and the infilled scours are overlain by thin-bedded, rippled, burrowed, quartz arenite interbedded with dark gray, silty shales and numerous bands of siderite, all of which have been mapped as Pennsylvanian Raccoon Mountain Formation. The upper portion of this lithologic complex is marked by chaotically arranged, large-scale slump blocks, or slump structures, which result in a highly irregular upper surface of the Raccoon Mountain that may be considered as a localized unconformity.

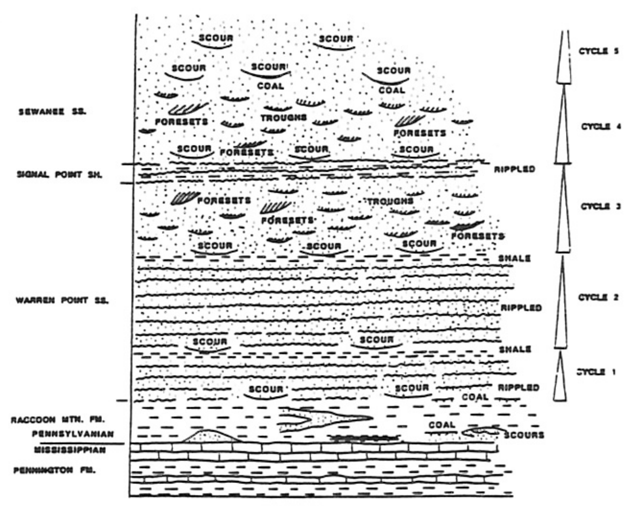

FIG. 3. Schematic of sedimentary structures at Monteagle Mountain roadcut, westbound lane, Interstate 24.

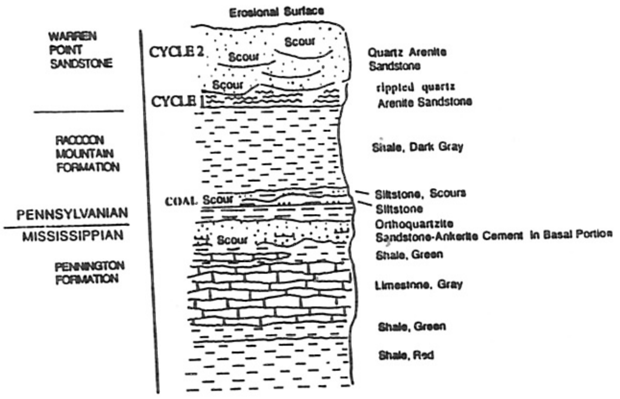

FIG. 4. Schematic of sedimentary structures of roadcut at eastbound lane of Interstate 24, east side of Monteagle Mountain.

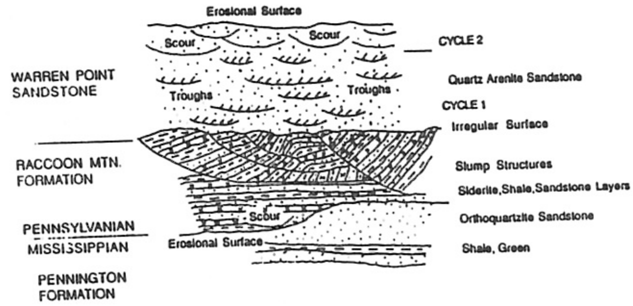

FIG. 5. Schematic of sedimentary structures of roadcut at eastbound lane of Interstate 24, west side of Monteagle Mountain.

The sandstone body overlying the slumped, lithologic complex (Raccoon Mountain Formation) is considered as part of the Warren Point Sandstone and is made up of vari-sized and vari-shaped trough crossbedded, sedimentary structures. Near the erosional top of the Warren Point are scours infilled with structureless, quartz arenite. The trough crossbedded units likely represent one cycle of sedimentation, and the scours near the top of the roadcut exposure mark the beginning of a second cycle.

INTERPRETATION

Figure 6 shows the correlation of three roadcut exposures of Carboniferous rocks on Monteagle Mountain, Tennessee. The westbound lane of Interstate 24 (marked A) and the eastbound lane of Interstate 24 (marked B) are located on the east side of the mountain. The eastbound lane of Interstate 24 (marked C) is situated on the west side of the mountain.

Mississippian Pennington Formation--The uppermost Mississippian Pennington Formation consists of thin-bedded limestone and black shale in exposure A. Red and green shale, thin-bedded limestone and a unique ankerite-cemented, massive bedded, fining upward orthoquartzite with a scoured base (local unconformity) mark exposure B. A massive-bedded orthoquartzite with a clay paste (kaolin) matrix is interbedded, near its base, with green shale in exposoure C. These Pennington exposures are considered as a high intertial, tidal flat complex with offshore orthoquartzite barriers or bars. The nature of the Mississippian-Pennsylvanian systemic contact in these three exposures is considered to be, with localized exceptions, transitional.

Pennsylvanian Raccoon Mountain Formation--Marginal marine accumulations characterize the lowermost Pennsylvanian Raccoon Mountain Formation in exposures A, B, and C. This interpretation is in agreement with Briggs and Eason (1972).

In exposure A, a mound-shaped quartz arenite offshore bar rests sharply on Pennington tidal flat carbonates. This may be viewed as a very local unconformity, but landward (east or northeast) of this bar are localized, restricted backbar deposits of red and green fossiliferous (brachiopods, bryozoans, and crinoids) shale and a 0.61-m thick, fossiliferous, red limestone, all of which grade upward into thick, dark-gray shale that formed as nearshore lagoon-fill or bay-fill. Up in this dark shale unit, above the offshore bar, is another quartz arenite bar with an unusual two-pronged morphology. Landward of the backbar deposits, at essentially the same stratigraphic level, a thin, coal seam (records a time of stillstand) overlies tidal channel, quartz arenite scourfill. At the top of the Raccoon Mountain, there is a swamp deposit of thin coal and associated rooted seatearth.

Exposure B shows marginal marine swamp deposits of dark gray siltstone capped by a thin coal. Laterally, the coal and the upper part of the siltstone body have been removed by siltstone-filled scour structures. Bay-fill, or lagoon-fill, of thick, dark gray shale make up the remainder of the Raccoon Mountain.

Tidal flat sequences of thin beds of gray, silty shale, quartz arenite, and maroon siderite form most of the Raccoon Mountain in exposure C. Scours associated with tidal channels are filled with quartz arenite and are located at the base of this stratigraphic unit, where they form localized erosional contacts by scouring the upper surface of the underlying Pennington orthoquartzite offshore bar.

The upper portion of these Raccoon Mountain tidal flats were deeply scoured by tidal channels, and, subsequently, the channel walls slumped into the former channel(s). The chaotic arrangement of these slump blocks has formed a highly irregular upper surface that gives the impression of a profound unconformity.

Pennsylvanian Warren Point Sandstone, Signal Point Shale, and Sewanee Sandstone--As mentioned previously, Briggs and Eason (1972) considered the Warren Point, Signal Point, and Sewanee formations to be associated with tidal delta deposits. However, the hierarchy (arrangement) of sedimentary structures in these stratigraphic units favors braided stream facies. Further, trough-crossbedded sedimentary structures in these rocks show a unimodal pattern indicative of stream flow

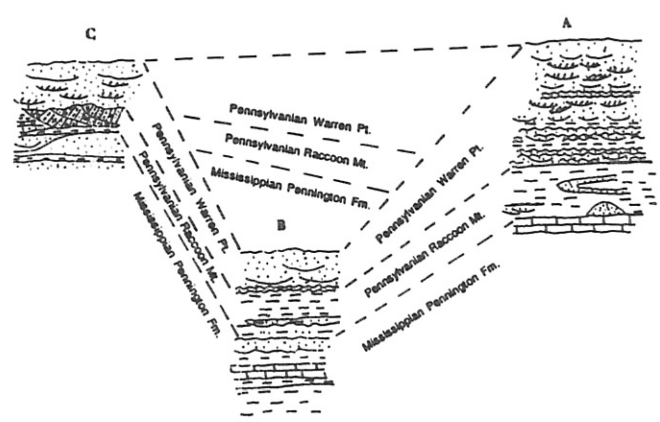

FIG. 6. Correlation of schematics of Carboniferous rocks exposed in roadcuts on Monteagle Mountain.

rather than the bimodal pattern of herringtone structures in trough crossbeds, that are related to flood and ebb tidal currents, which one would expect to find in flood tidal or ebb tidal delta deposits. Walker and Cant (1983) reviewed their work on the modern, braided South Saskatchewan river in Canada and proposed three series of sedimentary structure sequences that might characterize the South Saskatchewan.

The first sequence is considered as a channel sequence consisting of a basal lag (scours), overlain by trough cross stratification (troughs), associated with planar tabular crossbedding formed by cross channel bars. The second sequence, or sand flat sequence, also begins with basal lags (scours), and a trough-crossbedded sand sequence (troughs) overlain by sand flat deposits formed by preservation of a cross channel bar with sand flats accumulated atop the bar. Walker and Cant (1983) suggest that a spectrum of sedimentary structure sequences exist between the end-member channel and sandflat sequences. They present a third sequence, a mixed-influence sequence, that begins as a channel sequence of scours, troughs, and bars followed by sandflat structures. Finally, the sandy tops of these three sequences are made up of small planar and trough crossbeds as well as rippled sands.

In addition,.Cant and Walker (1983) discussed their work on an ancient fluvial deposit known as the Devonian Battery Point sandstone in the Quebec Appalachians of Canada. This deposit has been interpreted as a braided stream. They describe and interpret the Battery Point sedimentary structure sequences as a channel floor lag (scours) overlain by trough-crossbedded units (troughs) associated with planar tabular units (bars). This hierarchy is considered as in-channel deposits. Bar top deposits include small sets of planar tabular crossbeds as well as a thin record of crosslaminated siltstones interbedded with mudstones. Finally, Walker and Cant (1983) make the following general statements regarding braided streams: a braided stream will likely occupy a wide area; coalescing cross channel bars and sand flats result in laterally continuous and extensive sandsheets that are not bounded on all sides by shales (as sand deposits in meandering streams are); vertical accretion deposits (largely shales) tend to be quickly eroded because of relatively rapid lateral channel migration, and, thus, preserved shales are patchy and laterally discontinuous.

Therefore, armed with the work of Cant and Walker (1985), five prograding cycles of fining-upward sequences of quartz arenite sandstone (minor dark gray shale and siltstone) braided stream deposits have been recognized in exposure A (Figs. 3 and 6). Cycles 1 and 2 and most of cycle 3 are mapped as Warren Point Sandstone. The thin-bedded, rippled, dark gray siltstone in the upper part of cycle 3 is considered as Signal Point Shale. These shale and siltstone units have a patchy distribution and are laterally discontinuous. Thus, consistant identification and mapping of the Signal Point Shale stratigraphic unit was a problem for Moore and Briggs (1979) as they mapped the Monteagle Quadrangle. Cycle 4 and the lower part of cycle 5 (erosional upper surface) mark the Sewanee Sandstone.

Cycles 1 and 2 begin with scattered, broad, shallow scours and fine-upward through thin-bedded, rippled quartz arenite to thin beds of shale. These cycles are sandflat deposits of very shallow, widespread, braided streams with sufficient regional gradient to be of shale. These cycles are sandflat deposits of very shallow, widespread, braided streams with sufficient regional gradient to be considered as distal (far from source area) braided deposits. These sandflats are traversed locally by shallow channels and represent braided stream deposits that began to prograde over and inundate marginal marine lagoons. An ancient local slough in the sandflats is marked by a thin, coal seam with rooted seatearth. Thin shales atop cycles 1 and 2 represent local vertical accumulation deposits atop extensive sandflats. Basal, thin-bedded, rippled, quartz arenite layers of cycle 1 show vertical burrows (1 cm in diameter). No in-channel scours, troughs, or cross channel bars are present because of the shallowness of the braided stream. Cycle 3 shows numerous, broad, shallow scours at the base which are overlain by a thick series of vari-sized and vari-shaped trough crossbeds and foreset beds (planar tabular) which are, in turn, overlain by thin-bedded, rippled, dark gray siltstone (mapped as Signal Point Shale). These scours, troughs, and foresets (cross channel bars) are an in-channel sequence of a braided stream. The siltstone accumulated in a slough on a sandflat.

Higher in the Pennsylvanian stratigraphic sequence on Monteagle Mountain, in the upper portion of the Sewanee Sandstone (erosional upper surface), an exposure just inside the entrance to the University of the South at Sewanee shows a sedimentary structure that has been interpreted by Bergenback (1978) as a megaripple. However, in the light of more recent understanding, this structure represents an in-channel bar in a braided river of greater depth than deposits of exposures A, B, and C. This suggestion seems reasonable because, by the time this in-channel bar was formed, progradution of Pennsylvanian deposits had proceeded much farther to the west, and depth of braided river channels was greater.

Cycle 4 is similar to cycle 3, except that thin-bedded, rippled sandstone of siltstone beds do not cap cycle 4. Presumably, these sandflat deposits were locally eroded by large-scale scours of cycle 5 (upper units of cycle 5 have been eroded). Certain of the large scours in cycle 5 have thin (7.6 to 10.2 cm) coal at the base of their structureless, quartz arenite infilling. This situation indicates in-channel sequences with temporary channel abandonment aiding formation of very localized peat bogs in the abandoned channels. Subsequently, the braided stream switched channels and the abandoned channels were infilled with sand that facilitated compaction of peat to form bituminous coal.

The Warren Point Sandstone (erosional upper surface) is present in exposure B (Figs. 4 and 6) and is composed of thin-bedded, rippled quartz arenite (cycle 1) that grades into underlying, dark gray shale. Cycle 1 deposits are considered to be sandflat deposits of very shallow, widespread, braided stream units that prograded over marginal marine lagoons in a similar manner to cycle 1 of exposure B. Large-scale scours of cycle 2 scour into rippled layers of cycle 1. These large-scale scours are in-channel deposits of a braided stream.

Exposure C (Figs. 5 and 6) contains parts of two cycles of in-channel, braided stream deposits. Trough crossbeds of cycle 1 directly overlie the irregular surface formed by the chaotic arrangement of slump blocks in the underlying Raccoon Mountain. Quartz arenites infill large-scale scours in overlying cycle 2.

CONCLUSIONS

Three roadcut exposures of Carboniferous (Upper Mississippian-Lower Pennsylvanian) rocks are located within an area of appoximately 158 km² along westbound and eastbound lanes of Interstate 24 on Monteagle Mountain in eastern Tennessee (Fig. 2). The upper Mississippian Pennington Formation tidal flat complex contains red (oxidized), green, and black (reduced) shales along with thin-bedded, near-shore carbonates as well as orthoquartzitic offshore bars. With local exeptions, the Mississippian-Pennsylvanian systemic contact here is transitional (Figs. 3-6). Marginal marine characteristics are featured in the Lower Pennsylvanian Raccoon Mountain Formation. There are tidal flat sequences of thin-bedded, silty shale, sandstone and siderits with associated chaotically arranged slump blocks, and bay-fill dark shales that contain quartz arenite sandbars and tidal channel infillings along with marginal marine swamp deposits of coal and siltstone.

The Pennsylvanian Warren Point Sandstone, Signal Point Shale, and Sewanee Sandstone formations were deposited as braided stream complexes made of partial to complete cycles of sedimentary structures ranging, in a vertical sense, from in-channel basal scours, trough crossbeds (nee megaripples), and cross channel bars through rippled sandflats to vertical accumulations of siltstone and shale. It may be that basal scours in cycles 4 and 5 of the braided stream cycles may mark oscillations (e.g., midcontinent cyclothems), but, without very precise paleontologic control, the detailed correlation of scour structures among three roadcut exposures within a 158-km^2 area is impossible. Therefore, inasmuch as data are limited, it seems reasonable to suggest that the scour structures in this area represent localized gaps in the rock record and are simply related to channel switching within a braided stream complex.

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