LOWER PENNSYLVANIAN-UPPER MISSISSIPPIAN DEPOSYSYSTEMS, 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, Fern 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 Pennsylvania 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 (sidereite-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 coalbedding, dark gray shale. This situation clearly 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 cycles 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 silt-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
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-beded, fragmental limestones and scour-filling dolomictites.

At the top of the Pennington, there is a unique, white, quartz-rich sandstone body (orthooquartzite) that displays a scoured base filled with massive, structureless, coarse sand that contains what appear to be granule-sized, red-maroon siderite clasts. This orthooquartzite unit "fining upward" with small-scale, rippled layers of fine-grained, largely angular quartz sand and 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 siderite (an iron-bearing dolomite). Thus, the so-called siderite clasts are actually diagenetic growths of siderite 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 orthooquartzite, then the systemic boundary is unconformable. However, if the boundary is placed at the top of the orthooquartzite, then the contact may be viewed as transitional. I have chosen to place the contact at the top of the orthooquartzite.

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 orthooquartzite. 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-beded, 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-beded, 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 orthooquartzite 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 correclative with the orthooquartzite deposit described from the roadcut beside eastbound Interstate 24 on the east side of Monteagle Mountain. A portion of the upper surface of this orthooquartzite unit has been scoured and infilled with quartz arenite sandstone. Both the orthooquartzite unit and the infilled scours are overlain by thin-beded, 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.
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.

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

**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-beded limestone and black shale in exposure A. Red and green shale, thin-beded limestone and a unique ankerite-cemented, massive bedded, fining upward orthoquartzite with a scoured base (local unconformity) mark exposure B. A massive-beded orthoquartzite with a clay paste (kaolin) matrix is interbedded, near its base, with green shale in exposure C. These Pennington exposures are considered as a high intertidal, 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, silt 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. 5.** Schematic of sedimentary structures of roadcut at eastbound lane of Interstate 24, west side of Monteagle Mountain.

**FIG. 6.** Correlation of schematics of Carboniferous rocks exposed in roadcuts on Monteagle Mountain.
rather than the bimodal pattern of herringtonite 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 cross bedding formed by cross channel
bars. The second sequence, or sand flat sequence, also begins with basal
lags (scours), and a trough-crossbedded sand sequence (trenches)
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 (trenches) 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 cross laminated siltslone 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 sandsheds 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 (1983), five
prograding cycles of fining-upward sequences of quartz arenite sand-
stone (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 shales and siltsone units have a patchy
distribution and are laterally discontinuous. Thus, consistent identification
and mapping of the Signal Point Shale stratigraphic unit was a
problem for Moore and Briggs (1979) as they mapped the Montagle
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 seafloor. 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 Pennsylvania stratigraphic sequence on Montagle
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 Bergenbark (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, progradation of Pennsylvania 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
siltstone 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 Pennsylvania) rocks are located within an area of approximately
158 km² along westbound and eastbound lanes of Interstate 24 on
Montagle Mountain in eastern Tennessee (Fig. 2). The upper Missis-
sippian Pennington Formation tidal flat complex contains red (oxi-
dized), green, and black (reduced) shales along with thin-bedded,
near-shore carbonates as well as orthoquartzite offshore bars. With
local exceptions, 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 silt, with
associated chaotically arranged slump blocks, and bay-fill dark
shales that contain quartz arenite sandbars and tidal channel inflowings
along with marginal marine swamp deposits of coal and siltstone.

The Pennsylvania 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-km² 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.

LITERATURE CITED


