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OVERVIEW

The traverse from Natural Bridge State Resort Park to just north of Hazard covers a distance of 95 kilometers (59 miles) (Fig. 1). Stops in the Lower and Middle Pennsylvanian Lee and Breathitt Formations examine a variety of fluvial and deltaic facies, diagenetic features, and plant fossils. The Breathitt is the major coal-producing formation in eastern Kentucky, with over 80 million metric tons produced annually (Rice and others, 1979).

A natural bridge in sandstone of the Lee Formation is the first stop on this traverse. The trip will proceed by foot from the Hemlock Lodge to Stop 1. The trail to the bridge climbs approximately 110 meters (360 feet) over a distance of 0.8 kilometer (0.5 mile). For a fee, a chairlift can also be taken up to the bridge from the north side of the park.

Leaving Natural Bridge State Park, the field trip route moves up section from the Mississippian Borden Formation to the Pennsylvanian Breathitt Formation. Once the traverse enters Wolfe County (mile 5.7), the remainder of the route for Day 4 is in the upper member of the Breathitt Formation.

A second stop north of Jackson, Kentucky examines lower delta-plain facies in the Breathitt. These include distributary and crevasse-splay deposits.

The last stop of the traverse is a 115-meter high roadcut in the upper Breathitt Formation. At this cut north of Hazard, a three-dimensional view of lower delta-plain sandstone, shale, and coal can be seen.

TRIP LOG

Depart on foot from Hemlock Lodge, Natural Bridge State Resort Park. Walk south through the parking lot in front of the lodge until the pavement ends. Continue on a wide trail at approximately the same elevation as the parking lot.

Turn right at Trail No. 1, "The Original Trail", southwest towards Natural Bridge. The climb to the bridge starts in shale of the upper Borden Formation, crosses limestone and dolomite of the Slade Formation (Renfro Member of the Borden Formation and Newman Limestone of earlier nomenclature), then climbs through shale and siltstone of the lower
Breathitt Formation, and finally reaches the well-exposed sandstone and conglomerate of the Corbin Sandstone Member of the Lee Formation.

Figure 1. Field trip route for Day 4 from Natural Bridge State Resort Park to north of Hazard, Kentucky.
STOP 1 - NATURAL BRIDGE, NATURAL BRIDGE STATE PARK

The natural bridge is formed in the Corbin Sandstone, which is over 75 meters (47 feet) thick here (Rice, 1984). The Corbin ranges from a very fine- to medium-grained sandstone, to a pebble conglomerate. The pebbles are predominantly quartz, with lesser amounts of chert. In addition to siliciclastic grains, plant stem and trunk impressions occur locally.

The following features can be observed here:

- Examine the composition of this sandstone. Like other sandstones of the Lee Formation, the Corbin is composed of over 90% quartz (Rice, 1984). This contrasts with the more micaceous, feldspathic and lithic sandstones observed at Peach Ridge (Day 1, Stop 1), and those to be observed at Stops 2 and 3 on Day 4. Fern and others (1971) and Horne (1979) have interpreted the Corbin and other quartz arenites ("orthoquartzites") of the Lee Formation as beach-barrier island deposits whose high quartz composition is the result of continual reworking and winnowing in a high-energy environment. While this hypothesis, that beach and shoreface processes strongly influence the mineralogic maturity of a sandstone, has a long history (Folk, 1960; Pettijohn and others, 1972), there is little published evidence that nearly pure quartz sands are being produced in this manner today.

On the contrary, recent investigations of the mineralogy of modern beaches and rivers in South America (Franzinelli and Potter, 1983; Potter, 1984) suggest that the composition of the parent material and climate of the source terrain exert major controls on sand composition. Houseknecht (1980) and Rice (1984) provide evidence that this is also the case for the Lee and correlative New River quartz arenites.

- While the framework composition of the Corbin Sandstone is predominantly quartz, the cement is not. Locally extensive iron oxide and oxyhydroxide cementation is common. This cementation can take the form of Liesegang rings, rhythmic bands of iron oxide that result from the interdiffusion of Fe (II) and dissolved oxygen (Berner, 1980). These two ions diffuse from different sources and precipitate at a given site when concentrations exceed a threshold value.

- The cemented sandstone on some cliff faces develops a honeycomb weathering surface. Recent work by Mustoe (1982) indicates that this feature is formed by a combination of salt weathering and algal growth. Green algae bind the thin walls between the cavities in the rock, while salt precipitation is thought to cause the disaggregation of the sandstone. However, the evidence for salt weathering is more circumstantial, that is that honeycomb weathering is common in coastal and desert areas where salt efflorescence on rock surfaces also occurs. While the efficacy of salt weathering has been demonstrated experimentally (Cooke, 1979), it is not clear that it is the
only, or even primary mode, of rock disaggregation here.

- Examine the type and geometry of the cross stratification on top of and below the natural bridge. Questions to be addressed include:

(1) What type of cross stratification is present? Trough cross-bedding typically has bounding surfaces (surfaces that define the upper and lower extent of the cross laminae) that are undulatory in cross section parallel to flow. Tabular cross-bedding has bounding surfaces that are planar and parallel over long distances in the direction of flow. On the top of the bridge the cross sets can be seen in plan view. Where trough cross-stratification is present, rib and furrow structures occur.

(2) What is the paleocurrent direction here? In this area, Rice (1984) indicates paleocurrents in the Corbin flow to the southwest and west. Are the current indicators essentially unidirectional? If the Corbin represents deposition by tidal inlet migration of a barrier island, some paleocurrent reversals might be expected.

(3) What is the greatest height of the cross stratification here? The height of cross bedding places some constraints on water depth at the time of deposition.

(4) What do grain-size trends and sedimentary structures suggest about the depositional environment of the Corbin Sandstone? There is little published information on the internal characteristics of this unit. Previous interpretations of its depositional environment (beach-barrier bar, fluvial channel, or distributary channel) are based on regional stratigraphic relationships rather than a detailed sedimentologic study of the sand body.

Road Log - Day Four

0.0  Return down "The Original Trail" to Hemlock Lodge. The base of the hill behind the parking lot is in the Upper Mississippian Slade Formation. From the parking lot, the road descends through the Nada and Cowbell Members of the Mississippian Borden Formation.

0.4

0.4  Cross the Middle Fork of the Red River. Turn left (west) onto Kentucky Highway 11.

0.1

0.5  For the next 1.6 miles, roadcuts on the right are in the Cowbell Member of the Borden Formation.

0.9

1.4  Turn left onto the entrance ramp of the Mountain Parkway to Campton, Kentucky.
Road Log - Day Four

0.2
1.6 For the next mile, roadcuts are in the Cowbell Member of the Borden Formation.

1.2
2.8 Variegated shale of the Nada Member of the Borden Formation on the right.

0.2
3.0 Nada Member of the Borden Formation and overlying Renfro Member of the Slade Formation are exposed on the left.

0.1
3.1 Renfro Member is exposed between the Parkway and the frontage road that is higher on the cliff to the right.

0.1
3.2 Light-colored limestone of the Slade Formation on the left.

0.3
3.5 Channels in the lower member of the Breathitt Formation on the right.

0.2
3.7 Multiple coals in the lower member of the Breathitt Formation on the right.

0.2
3.9 Coals in the lower member of the Breathitt Formation overlain by sandstone of the Corbin Sandstone Member of the Lee Formation.

0.1
4.0 Cross-stratified Corbin Sandstone on the left.

0.4
4.4 Corbin Sandstone on both sides of the road for the next mile.

0.3
4.7 Enter Wolfe County.

0.1
4.8 Upper member of the Breathitt Formation on the right.

0.2
5.0 Small channels in the upper member of the Breathitt Formation on the right.

1.7
6.7 Roadcuts are in the upper member of the Breathitt Formation for the next 3.7 miles.

4.6
11.3 Exit to the right onto Kentucky Highway 15 (Exit 43) to Campton.

0.3
11.6 Roadcut in the upper member of the Breathitt, approximately 8 meters above the Lee Sandstone.

0.5
12.1 Enter Campton, the county seat of Wolfe County.

0.4
12.5 Junction with Kentucky Highway 191.

0.1
12.6 Shales in the upper member of the Breathitt on the right.

0.2
12.8 Thin coal in the upper Breathitt Formation on the right.
Road Log - Day Four

0.5
13.3 Interbedded sandstone and shale in the upper Breathitt. Siderite nodules occur in the shale.
2.1
15.4 Thick sandstone in the upper member of the Breathitt Formation on the left.
0.2
15.6 Upper Breathitt sandstone and shale on the right.
1.1
16.7 Thick sandstone in the upper Breathitt on the left.
2.3
19.0 Enter Bethany, Kentucky.
0.2
19.2 Junction Highway 1261. Shale in the upper Breathitt on the left.
0.7
19.9 Shale in the upper member of the Breathitt Formation on the left.
1.0
20.9 Enter Breathitt County.
0.6
21.5 Roadcuts in the upper Breathitt for the next 1.1 miles contain black and gray shale, sandstone, and concretions of siderite.
1.5
23.0 Enter Vancleve, Kentucky.
0.2
23.2 Junction Kentucky Highway 205. Exposures for the next 4 miles are in the upper member of the Breathitt, in the vicinity of the Vancleve coal.
3.9
27.1 Stop 2 - Rest Area North of Jackson, Kentucky

REST AREA NORTH OF JACKSON, KENTUCKY

This cut exposes delta-plain facies of the Breathitt Formation, 13 to 15 meters (40-50 feet) above the Lee Formation (Horne and others, 1971). The discussion here emphasizes the 0.6 kilometer (0.4 mile) of roadcut across from and northwest of, the rest area.

The following features are worthy of note at this exposure:

- First examine the bedding thickness and grain-size trends in this section. An important distinction can be made between packages of rock that coarsen upward, with an associated increase in bedding thickness, and those that fine upward from an erosional scour. The former packages suggest progradation of a crevasse splay or deltaic sublobe, while the latter indicate the aggradation and eventual avulsion of a channel. In this case, the channel is most likely a distributary.
- Look closely for evidence of bioturbation in the mudrock and very fine sandstone. Intense burrowing might suggest oxygenated, brackish- to normal-marine interdistributary bay deposition, in contrast to black shale, which could form in restricted (anoxic) interdistributary or lacustrine settings. Also look for unstratified mudstone, where rooting and/or subaerial exposure has destroyed depositional laminations.

- Inspect closely the lowermost portion of the distributary sandstone. What are the clasts in the channel lag composed of? Also, look for large blocks of siderite-cemented rock that have been incorporated into the channel-fill. The ferrous iron in siderite oxidizes upon weathering, and thus the exterior of the black sideritic ironstone appears brown in color. The geometry and distribution of the ironstone bands indicates that the cementation occurred before the blocks of sediment slumped into the distributary channel. This type of syndepositional cementation, referred to as "marshrock" by Pye (1981, 1984), occurs in salt marshes where rapid sedimentation traps organic matter. In this environment, the abundant sulfate in marine water is rapidly reduced by bacteria to form iron sulfides (Pye, 1981). Once the sulfide concentration of the pore water has been nearly eliminated, siderite precipitation can begin. This process must occur faster than additional marine sulfate can diffuse into the sediment. In salt marshes of Norfolk, England, where rates of sedimentation are 1.0 - 1.7 centimeters per year, siderite layers up to 25 centimeters in thickness have formed in 30 years (Pethick, 1981; Pye, 1981).

- Finally, examine the cross stratification in the thick "channel" sandstone. In which direction was the distributary channel flowing? Is this roadcut parallel or perpendicular to the paleoflow direction?

Road Log – Day Four (Cont’d)

27.1 Exposures for the next 2.6 miles are in the upper member of the Breathitt Formation.
    2.7
29.8 Junction with Kentucky Highway 30.
    0.4
30.2 Enter Jackson, Kentucky, the county seat of Breathitt County. Jackson has a population of approximately 2,700, and is the home of Lee College, a private junior college affiliated with the Presbyterian Church. Lee College was founded in 1927 and has an enrollment of 350 students. It has a curriculum in mining and reclamation technology, along with other career, pre-professional, and liberal arts programs.
    0.4
30.6 Pan Bowl Lake, an incised oxbow of the North Fork of the Kentucky River, on the left.
Road Log - Day Four

1.0
31.6 Upper member of the Breathitt Formation on the left. For the next 7 miles sandstone, shale, and coal of the upper member of the Breathitt Formation are exposed in roadcuts. This part of the section has been interpreted as lower delta-plain distributary and interdistributary bay deposits by Horne and others (1971).

8.3
39.9 Enter Lost Creek, Kentucky.

0.5
40.4 Junction Kentucky Highway 476.

0.7
41.1 Exposures of the Kendrick Shale Member of the Breathitt Formation on the left. Large limestone nodules are common in this unit. Similar nodules occur in the Magoffin Member at Stop 3. The Kendrick Shale has been interpreted as a "marine zone" on the basis of faunal (Chesnut, 1981) and geochemical evidence (Brand, 1983). It should be noted that the use of the term "marine zone" in eastern Kentucky includes both normal marine and brackish water deposits (Chesnut, 1981).

2.2
43.3 Siderite concretions in the upper Breathitt shale on the left.

1.8
45.1 Enter Ned, Kentucky.

7.3
52.4 Junction Kentucky Highway 28 to Buckhorn State Resort Park.

4.1
56.5 Hazard coal zone on the left.

0.7
57.2 Junction with Kentucky Highway 267.

0.6
57.8 Stop 3 - Exit to the right onto Daniel Boone Parkway.

HAZARD NORTH ROADCUT

The roadcuts at this highway interchange expose sandstone, mudrock, and coal of the Breathitt Formation, from the Magoffin Member at the base to the Hindman coal bed near the top (Fig. 2 and Fig. 3). Caution: Beware of traffic and unstable highwalls here! One speeding coal truck can ruin your entire day! Much of the geology here is visible from the road and climbing is not necessary. If you must climb to any of the higher benches, do so at your own risk and be considerate of your colleagues below.

The following features can be observed, starting from the base of the section on the access road at the northwest corner of the interchange (Fig. 2):

- Examine the thinly bedded, very fine sandstone of the Magoffin Member on the exit ramp. Both the large carbonate concretions and the stratification are distinctive in this unit. Two types of concretions are present: tabular siderite "ironstone" and
ellipsoidal calcite. Sparry calcite cement occurs in septarian fractures within the ellipsoidal calcite concretions. Study the concretions and their relationship to the surrounding shale. What is the order of mineral growth (paragenesis)? Did these concretions form early or late in the diagenesis of this rock?

This thinly bedded, upward-coarsening sequence is suggestive of a low-energy, interdistributary bay deposit at the distal end of a crevasse splay. A diverse macrofauna of mollusks, brachiopods, bryozoa, echinoderms, and coelenterates occurs in nearby roadcuts along the Daniel Boone Parkway (Dennis and Lawrence, 1979). This suggests that, at least locally, the Magoffin is a normal marine deposit. Like the younger Kendrick Shale, many Magoffin mollusk shells contain aragonite (Dennis and Lawrence, 1979).

Preservation of aragonite is rare in Paleozoic rocks because of its thermodynamic instability in pore waters other than seawater. Very early cementation of sediment would seem to be required to prevent dissolution of the aragonite by later pore water.

- What is the origin of the mottling in the uppermost portion of the Magoffin sandstone? The development of the thin Haddix coal fabove the sandstone may provide a clue. Chesnut (1981) notes the presence of a coal at the top of other "marine zones" in the Breathitt Formation.
Figure 2. Sketch of the northwest cut of the interchange between Kentucky Highway 15 and Daniel Boone Parkway (Stop 3, Day 4) in Perry County, Kentucky. After Cobb and others (1981).
Figure 3. Sketch of the northeast cut of the interchange between Kentucky Highway 15 and Daniel Boone Parkway (Stop 3, Day 4), Perry County, Kentucky. For an explanation of the symbols, see Figure 2. After Cobb and others (1981).
- The pelecypod Anthraconia (Naiadites) sp. and sharks' teeth have been found in the black shale above the Haddix coal (Cobb and others, 1981). This pelecypod is indicative of less than normal marine salinity (Chesnut, 1981).

- In the Haddix "coal zone" and above are numerous, irregularly shaped siderite nodules. These nodules weather out in the drainage ditches on the northwest and southwest sides of the intersection. Study the morphology of these nodules. Pye (1984) describes irregular siderite concretions over 30 centimeters in diameter with projecting root tubules in the salt marshes of Norfolk, England.

- Examine the sandstone between the Haddix and Hazard coal zones. In this sandstone are both casts and carbonized replacements of tree stumps. Large, sand-filled desiccation cracks in this bed indicate subaerial exposure of the vegetated surface before final burial. Rapid burial of trees by crevasse splay sands is a probable explanation for the preservation of the trees. The small channels within this stratigraphic interval may be crevasse channels.

- Cross the bridge to the southeast and northeast cuts (Fig. 3). At the top of the thick Hazard coal is a sharp, planar contact with an overlying sandstone. Study this contact and the cross-stratification within the sandstone. Was the flow that deposited the sandstone channelized here, or is the sand body a crevasse delta that prograded out over the peat? The absence of significant soft-sediment loading or scour at the base of the sandstone is striking. Was the peat a resistant mat of roots, similar to that suggested by McCabe (1985) to explain the durability of blocks of coal within channel sandstones?

Large-scale cross stratification occurs within the sandstone. These cross strata appear to dip generally to the west. Two hypotheses can be advanced to explain large-scale cross strata in this setting. The first is the accretion of sediment by the lateral migration of a point bar. These lateral accretion sets (epsilon cross strata) commonly coarsen upward from a channel lag at the base. The upper portion of each lateral accretion set may be draped with mudrock deposited on the upper part of the point bar. Paleocurrent flow along lateral accretion sets should be generally perpendicular to the dip of the large-scale cross strata.

The second hypothesis involves the progradation of a small delta, probably a crevasse delta, into several meters of standing water. As the delta builds rapidly outward and aggrades upward, both topset and foreset strata would be preserved. Thin mud drapes over the delta surface could occur between major flood events through the crevasse. Paleocurrent flow on such a delta should be essentially parallel to the dip of the large-scale cross strata.
Road Log – Day Four (Cont’d)

57.8 Mileage resumes at bridge under the Daniel Boone Parkway. Return north on Highway 15 to Kentucky Highway 28.

0.7

58.5 Junction Kentucky Highway 267 to Typo, Kentucky.

4.8

63.3 Turn left onto Kentucky Highway 28. Proceed west to Buckhorn Lake State Resort Park.

5.6

68.9 Roadcut to the left is in the upper member of the Breathitt Formation, in the vicinity of the Fire Clay coal. A thin coal is present in an abandoned channel. Cross bridge over the North Fork of the Kentucky River.

0.2

69.1 Cross railroad tracks into Chavies, Kentucky.

4.5

73.6 Turn left to Buckhorn State Resort Park.

1.4

75.0 Take left fork in road.

3.0

78.0 Buckhorn Lodge.

END OF DAY FOUR.

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FIELD GUIDE TO FOSSIL PLANTS OF EASTERN KENTUCKY

Thomas N. Taylor and Edith L. Smoot
Department of Botany, The Ohio State University, Columbus, Ohio

- Day 5 - Fossil Plants from the Pennsylvanian of Eastern Kentucky -

INTRODUCTION

We will proceed from Buckhorn Lake along Rt. 451 to the Daniel Boone Parkway just west of Hazard, Kentucky. Here we will head west along the Parkway to the Hyden exit. Along the Daniel Boone Parkway are some excellent high roadcuts that provide a partial view of the facies changes that occur both vertically and laterally within the Pennsylvanian strata. We'll continue along Rt. 421 heading south passing through the communities of Hoskinston, Asher, Mozelle and Bledsoe before turning east on Rt. 221, and heading to the Pine Mountain Settlement School where we will spend the night.

BREATHITT FORMATION

The Breathitt Formation is known to be nearly 1000 meters (0.62 mile) thick in parts of southeastern Kentucky and contains the majority of the economically important coals found in the region. There are up to 30 major coal beds or zones and correlation has traditionally been difficult due to the use of over 150 local names for the coals (Rice et al., 1979; Rice, 1981). In addition, Kosanke suggests that only a few taxa of palynomorphs found in these coals are potentially useful for regional or interregional correlation (Kosanke, 1965a, b, 1966, 1967, 1968, 1969, 1971, 1972). The formation contains carbonaceous shales with locally abundant compression-impression plant remains, as well as marine limestones containing brachiopods, pecelcypods, cephalopods, gastropods and crinoids. Some of these are visible in the limestone cap rock above the coal ball outcrop in Lewis Creek. The formation cannot readily be subdivided into lithologic units and key beds, such as marine limestones or coal beds which have been used for correlation from outcrop to outcrop (Rice, 1981). The Magoffin Member is one of the most important of these beds, because it is widespread and often contains very fossiliferous beds near the base, which can be recognized in drill cores (Rice, 1981). Until relatively recently, the Breathitt was seen as a discrete unit underlain by the sandstones of the Lee Formation. However, it is now generally subdivided into a lower tongue and an upper member that are separated by the rocks of the Lee (e.g., Ettensohn and Peppers, 1979). To date, coal balls are known only from the upper member of the formation.

PINE MOUNTAIN SETTLEMENT SCHOOL

We will be spending the night at the Pine Mountain Settlement School, one of the oldest continuously operating schools in the area. Pine Mountain was started in 1913 as a settlement school shortly after the first railroads came to Harlan County. The designation as settlement school indicated first of all that it was a boarding school (a necessity due to
the lack of roads in the area), but also that the school itself was a community. The children not only learned typical academic subjects, but contributed to making the school self-sufficient—they grew their own food, raised their own livestock, cooked, sewed, etc. From the beginning, there was an emphasis on maintaining many of the traditional Appalachian arts and crafts that were gradually dying out—skills such as spinning, weaving, and furniture making and performance of traditional folk songs and ballads. In addition to these areas, the school emphasized community service, providing some of the first health care in the area, and running a program in which high school students provided community service one or two days a week. Through the years, Pine Mountain Settlement School changed many times to keep pace with all the changes occurring in the area. As more roads and railroads were built, coal and timber companies moved in, providing employment for local people and also bringing many changes, not only to the mountain people and their way of life, but also to their surroundings. The Trustees of Pine Mountain early recognized a need to educate the people of the area in developing an understanding of environmental problems and in preserving their natural heritage. For these reasons, in 1972, Pine Mountain school was converted to an educational center and continues in that capacity today, serving not only students and teachers in the area, but visitors from all over the world. The school grounds are ideally suited to this purpose and include 800 acres of woodlands with many wildflowers and birds.

The purpose of this leg of the trip will be to visit two fossil plant localities of nearly equivalent age. At one site (Lewis Creek) structurally preserved plants are found in coal balls (petrifications or permineralizations). At the second locality, impression/compression specimens occur in a fine grained shale that is stratigraphically slightly older than the coal balls.

LEWIS CREEK COAL BALL SITE

The Lewis Creek, Kentucky coal ball locality was originally described by James M. Schopf in 1961, along with two other, similar localities in eastern Kentucky (Schopf, 1961). The site is a relatively massive creek-bed outcrop of the fossiliferous limestone approximately 1/4 mile above the confluence of the Left Fork and Lewis Creek (38°16'45", 37°0'15" Cutshin 7.5' Quadrangle, Leslie Co., [Ping, 1977]). Stratigraphically, the site was described by Schopf as below the Magoffin beds of Morse (1931) within the Copland (Taylor) coal. However, Ping (1977) places the outcrop in the center of the underlying Hamlin coal zone. This would be at least 21 meters (70 feet) below the Copland coal bed. Phillips (1980) includes the coal balls within the Copland coal. With the exception of a site in nearby Harlan County which occurs in association with the Upper Path Fork coal (Phillips and Chesnut, 1980; Cichan and Taylor, 1982b; Selin, 1982), the Lewis Creek site is older than any of the other Pennsylvanian coal ball localities in North America, and is represented by a flora that is distinctly different from any other Upper Carboniferous floras. The fossils occur below the Magoffin Member of the Breathitt Formation, which is considered to be Lower-Middle Pennsylvanian (Rice et al., 1979). Although Phillips (1980) describes this locality as Middle Pennsylvanian, correlating it with the Kanawha Formation of West Virginia, Rice and others (Rice et al., 1979; Chesnut, 1981) place both the Taylor and Hamlin coals
near the Morrowan-Atokan boundary (Lower-Middle Pennsylvanian). In addition, Gordon (in Outerbridge, 1976) describes the Magoffin Member as latest Morrowan to earliest Atokan based on faunal evidence. Based on the composition of the flora, Good and Taylor (1970) have suggested that this site is stratigraphically closer to Upper Carboniferous (Westphalian A-B) floras known from Europe than to any Middle Pennsylvanian (Westphalian C equivalent) floras in North America.

INTERPRETATION

Recent work on stratigraphy, palynology and environments of deposition in the area suggest that the Breathitt, together with the underlying Newman Limestone and Pennington and Lee Formations, are components of a major regional transgression dominated by carbonate deposition and a regression characterized by clastic deposition (Ettensohn, 1977; Ettensohn and Peppers, 1979). Ettensohn and Peppers (1979) suggest that these regional events were interrupted by tectonic activity and changes in sea level, resulting in a depositional environment that moved from carbonate-dominated shorelines in the Newman to deltaic shorelines in the Breathitt. However, Hester (1981) suggests that a river system model can best explain the facies changes and lithologic types seen in the lower Pennsylvanian of eastern Kentucky.

The depositional environment of the typical marine zones in the Breathitt, such as the Magoffin Member, has been described as a coarsening upward bayfill sequence (Chesnut, 1981). The base of the marine strata typically directly overlies a coal bed and represents the maximum extent of transgression. This marine sequence is then followed by a progradational sequence of deltaic sediments that coarsens upward and eventually includes coal beds or coal zones. The Magoffin Member marine depositional sequence is generally considered to have been deposited in a large open bay which transgressed over the Copland coal zone either due to subsidence or to eustatic change (Rice et al., 1979; Chesnut, 1981). Perm et al. (1971) have suggested that the depositional environment for the Breathitt Formation varies from lower delta plain (strata between Fire Clay-Whitesbury coal beds and Princess No. 6 coal) to alluvial plain (Princess No. 6, 7 and 8 coals). The Hamlin coal zone is the next major coal zone above the Fire Clay Rider and this would place the coal somewhere in the boundary between lower and upper delta plain depositional environments. Cobb et al., (1981), based on the presence of numerous plant fossils, in situ stumps, rooting structures and fining-upward sediments suggest a fresh-water fluvial origin for the Copland coal zone and associated strata, which directly overlie the Hamlin coal beds. However, the suggested depositional environment of the Magoffin Member indicates that the coal balls were probably deposited in a lower delta plain situation. In addition, the quality of cellular preservation seen in the Lewis Creek coal balls indicates that the plants must have been rapidly infiltrated by waters highly charged with calcium carbonate, indicating a relatively close proximity to marine influence.

Since the discovery of the site in the early 1960's, numerous collections have been made from Lewis Creek. Initially, the coal balls were taken out in rock sacks and pulled out on wooden sleds by mules. In 1965, in collaboration with D.A. Eggert, more extensive collections were
undertaken by our laboratory in which pneumatic drilling equipment and dynamite were used to remove the overlying marine limestone and to extract large quantities of coal balls. Through the use of earth moving equipment, it has also been possible to uncover more of the fossiliferous limestone adjacent to the initial site in the creek bed. These collections have provided the opportunity to characterize this stratigraphically and evolutionarily important flora of Upper Carboniferous age. One of the unique aspects of this flora is the exquisite cellular preservation of the plants (Figs. 1-12).

Many of the Lewis Creek coal ball plants have yet to be described in detail. Below is a list, together with the citation, of several floral components from this site. Several taxa are illustrated on Figures 1-12.

**Fossil Plants**

**LYCOPHYTA**
- Lepidostrobus schopfii (Brack, 1970)
- Endosporites (Brack and Taylor, 1972)
- Achlamydocarpone cf. belgicum (Taylor, 1974)
- Lepidocarpon takhtajanii (Taylor, 1974)
- Stigmaria sp. (Cichan, Taylor and Smoot, 1981)
- Lepidophloios sp. (Cichan, Taylor and Smoot, 1981)

**SPHENOPHYTA**
- Calamosatchys binneyana (Taylor, 1967)
- Bowmanites dawsoni (Taylor, 1969)
- Weissistachys kentuckiensensis (Rothwell and Taylor, 1971a, b)
- Sphenophyllum plurifoliatum (Cichan and Taylor, 1982c)
- Calamites sp. (Good, 1971)
- Calamocarpon insignis (Good, 1975)
- Arthropitys communis (Good, 1975)
- Arthropitys deltoides (Cichan and Taylor, 1983)
- Arthroxylon sp. (Good, 1975)

**PTERIDOSPERMOPHYTA**
- Feraxotheca culcita (Millay and Taylor, 1977, 1978)
- Stephanospermum costatum (Good, Rothwell and Taylor, 1982)
- Microspermopteris aphyllum (Taylor and Stockey, 1975)
- Pachytesta muncii (Cichan and Taylor, 1981)
- Medullosa anglica (Smoot and Taylor, 1981)
- Conostoma chappellicum (Stubblefield and Rothwell, 1980)

**CONIFEROPHYTA**
- Cordaites felicis (Good and Taylor, 1970)
- Mitrosporum compressum (Taylor and Stewart, 1964)
- Gothania lesliana (Daughlian and Taylor, 1979)
- Felixipollenites macroreticulata (Millay and Taylor, 1974)
- Sullisaccites kentuckiensis (Millay and Taylor, 1974)
- Premnoxyylon (Cichan and Taylor, 1982)
PTERIDOPHYTA

Botryopteris sp. (Millay and Taylor, 1982)
Etapertis lecercqii (Smoot and Taylor, 1978; Smoot, 1979)
Ankyropteris brongniartii (Mickle, 1980)
Psaronius sp. (Smoot, 1984)
Botryopteris tridentata (Smoot, 1979)

Fungi

Chlamydosporales (Wagner and Taylor, 1982)
Traquairia williamsonii (Stubblefield and Taylor, 1983)
Sporocarpus cellulosum (Stubblefield et al., 1983)
Sporocarpus asteroides (Stubblefield et al., 1983)
Dubiocarpus compactum (Stubblefield et al., 1983)
Coeleocarpus globosum (Stubblefield et al., 1983)

Below is a listing of additional structurally preserved fossil plants compiled from our master peel file of Lewis Creek coal balls. Alethopteris, Anachropteris involuta, A. clavata, Asterophyllites, Astromyelum, Botryopteris globosa, Cordaianthus, Dolerotheca, Heterangium, Lepidodendron, Lepidophylloides, Lepidostrobus galteri, Myeloxylon, Pachytesta sp., Palaeostachya, Paurodendron, Peltastrobus, Stigmaria, Stipitopteris, Tubicaulis.

IMPRESSION/COMPRESSION LOCALITY

There are several collecting sites close to the coal ball locality that have yielded abundant, well-preserved plants in recent years. Recently, limited mining activity has resulted in excellent shale exposures containing abundant plants, some with recoverable cuticle.

Although the compression/impression fossil plants from the shales in eastern Kentucky are abundant and well preserved, to date there has been relatively little attention directed at these specimens. Lesquereux (1861), Bode (1958) and White (1943) have provided floral lists of Pennsylvanian plants from eastern Kentucky, while Jennings (1981) has recently demonstrated the diversity of the flora from the region. The only other published report on plants from this stratigraphic level is that of Stubblefield et al., (1982) describing a new species of Crossotheca from the shales immediately below the Lewis Creek coal ball horizon.

Figures 13-23 illustrate some of the more common floral elements that will be encountered in the shales within the Breathitt Formation.
FIGURE EXPLANATIONS

Figures 1-3. Structurally preserved plants from the Lewis Creek coal ball site.

Figure 1. Longitudinal section of the sphenophyte cone *Calamostachys binneyana*. X 10.

Figure 2. Transverse section of the lycopod cone *Lepidostrobus schopfii*. X 7.

Figure 3. Transverse section of the sphenophyte cone *Weissistachys kentuckiensis*. X 14.
FIGURES 1 through 3.
FIGURE EXPLANATIONS

Figures 4-7. Structurally preserved plants from the Lewis Creek coal ball site.

Figure 4. Longitudinal section showing apex and leaf whorls of immature cone of Calamostachys binneyana. X 14.

Figure 5. Longitudinal section of the pteridosperm seed Pachytesta muncii. X 2.5.

Figure 6. Oblique longitudinal section of the lycopod cone Achlamydocarpon varius. X 4.5.

Figure 7. Transverse section of the petiole of Etapteris leclercqii. X 20.
FIGURES 4 through 7.
FIGURE EXPLANATIONS

Figures 8-12. Structurally preserved plants from the Lewis Creek coal ball site.

Figure 8. Section of stigmarian rootlet containing numerous fungal chlamydospores. X 20.

Figure 9. Transverse section of primary axis of the cordaites pollen cone Gothania lesliana. X 12.5.

Figure 10. Transverse section of the stem, axillary branch and petiole of the fern Ankyropteris brongniartii. X 6.5.

Figure 11. Transverse section of a portion of the vascular system of the marattialean fern Psaronius. X 6.5.

Figure 12. Transverse section of Premnoxylon wood showing numerous cavities containing boring arthropod fecal remains. X 27.
FIGURES 8 through 12.
FIGURE EXPLANATIONS

Figures 13-17. Impression/compression fossil plants collected from the shales near the Lewis Creek locality.

Figure 13. \textit{Pinnularia} sp. X 2.

Figure 14. \textit{Calamites} stem bearing several small cones. X 2.

Figure 15. \textit{Sphenopteris} cf. \textit{S. footneri}. X 1.5.

Figure 16. Small branch of \textit{Lepidodendron} \textit{aculeatum}. X 2.

Figure 17. Nodal diaphragm of \textit{Calamites undulatus}. X 2.
FIGURES 13 through 17.
FIGURE EXPLANATIONS

Figures 18-23. Impression/compression fossil plants collected from the shales near the Lewis Creek site.

Figure 18. *Alethopteris serlii*. X 1.5.
Figure 19. *Lepidodendron* with attached leaves. X 2.
Figure 20. *Lepidostrobophyllum lanceolatum*. X 2.
Figure 21. *Sphenophyllum majus*. X 2.
Figure 22. *Annularia* sp. X 2.
Figure 23. *Annularia radiata*. X 1.
FIGURES 18 through 23.
REFERENCES


Morse, W.C., 1931, Pennsylvanian invertebrate fauna of Kentucky, Kentucky Geol. Surv., ser. 6, 36: 293-348.


