Palynological Studies of Lower Pennsylvanian Coal Beds and Adjacent Strata of the Proposed Pennsylvanian System Stratotype in Virginia and West Virginia

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A report on the occurrence of Lower Pennsylvanian palynomorphs and their thermal alteration

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By ROBERT M. KOSANKE

ABSTRACT

The Lower Pennsylvanian Series of the proposed Pennsylvanian System stratotype in Virginia and West Virginia is composed of the Pocahontas and New River Formations. One hundred twelve samples of seat rock, coal, and roof rock were collected from 29 localities. Samples from 19 of these localities yielded palynomorphs. It has been possible to trace the range zones of *Lycospora noctuina* Butterworth and Williams and *Densosporites irregularis* Hacquebard and Barss upwards to coal beds associated with the Nuttall Sandstone Member near the top of the New River Formation. *Schulzospora rara* Kosanke is poorly represented in these samples, but the range zone of this taxon extends into the lower part of the Kanawha Formation or the Middle Pennsylvanian Series of the stratotype. The first Pennsylvanian occurrence of *Laevigatosporites* is near the top of the New River Formation close to the New River-Kanawha boundary. This fact may prove of value in the placement of this boundary in other areas of the Appalachian basin and elsewhere.

This investigation was an experiment to ascertain what palynological information could be obtained from organic matter that has undergone extensive thermal alteration. This alteration was most pronounced in the Pocahontas and lower half of the New River Formations. The color changes in palynomorphs from yellow and readily transparent to black and opaque is the result of thermal alteration. Organic matter preserved in non-coal lithologies, such as seat rock and roof shale, is less affected by thermal alteration than is organic matter preserved in coal. Consequently, most palynomorph data from the Pocahontas and lower half of the New River Formations were obtained from non-coal samples.

This report provides data relating palynomorph color to degree of thermal alteration as well as listing the occurrence of some selected taxa useful in correlation studies. It would be useful to augment this data with additional samples from Lower Pennsylvanian coal beds from southwestern Virginia which are known to yield more abundant and better preserved palynomorphs.

INTRODUCTION

This is the third in a series of four papers describing the palynomorph content of coal beds and adjacent strata in the proposed Pennsylvanian System stratotype of Virginia and West Virginia. The first paper (Kosanke, 1984), a survey of selected coal beds from the New River Formation to the basal part of the Monongahela Formation, examined changes in palynomorph content through a number of coal beds. It was followed by an intensive palynological study of the coal beds and adjacent strata of the Middle Pennsylvanian Series (Kosanke, in press). A previous investigation (Kosanke, 1984) established that palynomorphs could be extracted from non-coal samples of the Pocahontas and New River Formations, and from the Sewell coal bed of the New River Formation. Although the palynomorph assemblages recovered from these samples were rather limited, this part of the stratotype needed to be investigated because the section is as complete as is known and potentially of value for correlation purposes. From the beginning it was realized that it would be difficult to extract meaningful palynomorph yields from high rank coal beds of the Pocahontas Formation. However, the non-coal samples from the Pocahontas and lower part of the New River Formation do provide data concerning the continuity of range zones of important taxa. Palynological analyses reveal that the landscape was dominated by plants of Lycopsida origin. These plants were most often arborescent types, but occasionally herbaceous plants were abundant.

The samples for this investigation were collected from seven 7½ minute quadrangles in West Virginia and one 7½ minute quadrangle in Virginia. One hundred twelve samples were collected from 29 localities from the Bramwell Member of the Bluestone Formation, Pocahontas Formation, and the New River Formation. Productive samples were recovered from 19 of the 29 collecting localities and form the basis of this paper. Palynomorphs were recovered largely from non-coal samples of the Pocahontas and lower part of the New River Formations. The thermal alteration, as evidenced by color of palynomorphs, is recorded for each sample. In general, thermal alteration of palynomorphs decreases in stratigraphically younger samples.

ACKNOWLEDGMENTS

I am indebted to a number of Survey colleagues for their assistance in collecting the samples used in this investigation and for discussions on the stratigraphy of the Lower Pennsylvanian Series of the proposed Pennsylvanian System stratotype of Virginia and West Virginia. The colleagues who have particularly aided me are K. J. Englund, T. W. Henry, and H. H. Arndt. In addition, I would be most remiss if I failed to properly acknowledge the tireless efforts of B. J. LeMaster and Mary Ellen Zayhowski for their preparation of these difficult, high rank samples.

SAMPLE COLLECTION, PREPARATION, AND LOCALITIES

Samples for this investigation, as for previous investigations of the proposed Pennsylvanian System stratotype, were collected as uniformly as possible. Where available, seat rock, coal, and roof rock samples were collected as described by Kosanke (1977). Seat and roof rock samples can provide information concerning the composition of early swamp communities as well as information about the plants that existed after peat accumulation ceased. Standard procedures involve the collection of a ribbon sample in which the coal is divided into benches based on thickness or partings. An arbitrary maximum thickness of coal samples is set at 30 cm (1 ft) unless the coal sequence is interrupted by noncoal partings. Coal and parting samples are collected and prepared separately. This collecting method is applied to core, mine, or outcrop samples and provides the opportunity to trace changes in palynomorph composition throughout the entire cycle of coal deposition. More detailed information on this method of collecting samples is given by Kosanke (1977).

Samples were prepared in basically the same manner as previously discussed by Kosanke (1950, 1973, and 1984). However, the time required to oxidize the high rank coals of the Pocahontas and New River Formations is much greater. The details of sample preparation are recorded in USGS Denver Paleozoic Maceration books 16 and 17.

All of the prepared samples were assigned maceration numbers. Those macerations that yielded palynomorphs were assigned D numbers, USGS Paleobotanical locality numbers and recorded in D book number 5. In a previous investigation by Kosanke (1984) the palynomorphs present in the Sewell coal bed were reported and these samples were assigned a USGS Paleobotanical locality number. This D number is shown in parentheses to differentiate it from newly assigned D numbers of this report.

The samples used in this investigation are all from the proposed Pennsylvanian System stratotype of Virginia and West Virginia as described by Englund and others (1976), Englund and others (1977), and Englund, Arndt, and Henry (1979), and the geographic locality of these samples is shown in figures 1–3. The maceration numbers and USGS Paleobotanical locality numbers (D numbers) of the productive samples follows:

Upper Mississippian Series
- Bramwell Member, sampled at top and bottom and at 1.5 m intervals.
  - Calcareous shale and siltstone and basal black shale unit collected from the West Virginia Turnpike section, Stop 10 of Englund and others (1976), Flat Top 7½ minute quadrangle, Mercer County, West Virginia. This locality is on the east side of the Turnpike 3 3/4 miles south of the Mercer-Raleigh County line, D6668, macerations 742A–F.

Lower Pennsylvanian Series
- Pocahontas Formation
  - Unnamed coal bed below Pocahontas No. 1 coal bed, units 19 through 22, Garwood section, Stop 9 of Englund (1979) and Englund, Pfefferkorn, and Henry (1979) north of State Route 10, Crumpler 7½ minute quadrangle, Wyoming County, West Virginia. The location of the Garwood section is shown on figures 1 and 2, D6675, macerations 699A–C.
  - Unnamed coal bed below Pocahontas No. 1 coal bed, units 36 through 38, Garwood section, same geographic locality as preceding sample, D6676, macerations 701A–C.
  - Pocahontas No. 1 coal bed, Garwood section, units 46 through 48, same geographic locality as preceding sample, D6661, macerations 703A–C.
  - Pocahontas No. 3 coal bed from railroad spur located 1,463 m south of the north line of Dungannon 7½ minute quadrangle and 1,600 m west of the east line of the Dungannon quadrangle in Russell County close to the Russell-Scott County line, Virginia, D6660, macerations 743A–D.
  - Pocahontas No. 3 coal bed from along road cut along Virginia Route 63, close to preceding samples as shown on figure 1, Dungannon 7½ minute quadrangle, Russell County, Virginia, D6677, macerations 744A–C.
  - Pocahontas No. 4 coal bed, Garwood section, units 78–79, Stop 9 of Englund (1979) and Englund, Pfefferkorn, and Henry (1979) north of State Route 10, Crumpler 7½ minute quadrangle, Wyoming County, West Virginia. This location is shown on figures 1 and 2, D6674, macerations 713A–B.
  - Pocahontas No. 6 coal bed horizon, shale with plant fossils, Garwood section, unit 81, same geographic locality as preceding sample, D6673, maceration 715.
  - Pocahontas No. 6 coal bed from road cut located 1,175 m south of the north line of Bramwell 7½ minute quadrangle and 3,333.8 m east of the west line of Bramwell 7½ minute quadrangle, Mercer County, West Virginia, D6669, macerations 745A–D.
- New River Formation
  - Pocahontas No. 8 coal bed, Garwood section, Stop 9 of Englund (1979) and Englund, Pfefferkorn, and Henry (1979) north of State Route 10, units 126 through 128, Crumpler 7½ minute quadrangle, Wyoming County, West Virginia. This location is shown on figures 1 and 2, D6664, macerations 717A–C.
  - Pocahontas No. 9 coal bed from road cut located 1,717.8 m south of the north line of Bramwell 7½ minute quadrangle and 3,124 m east of the west line of Bramwell 7½ minute quadrangle, Mercer County, West Virginia, D6670, macerations 747A–F.

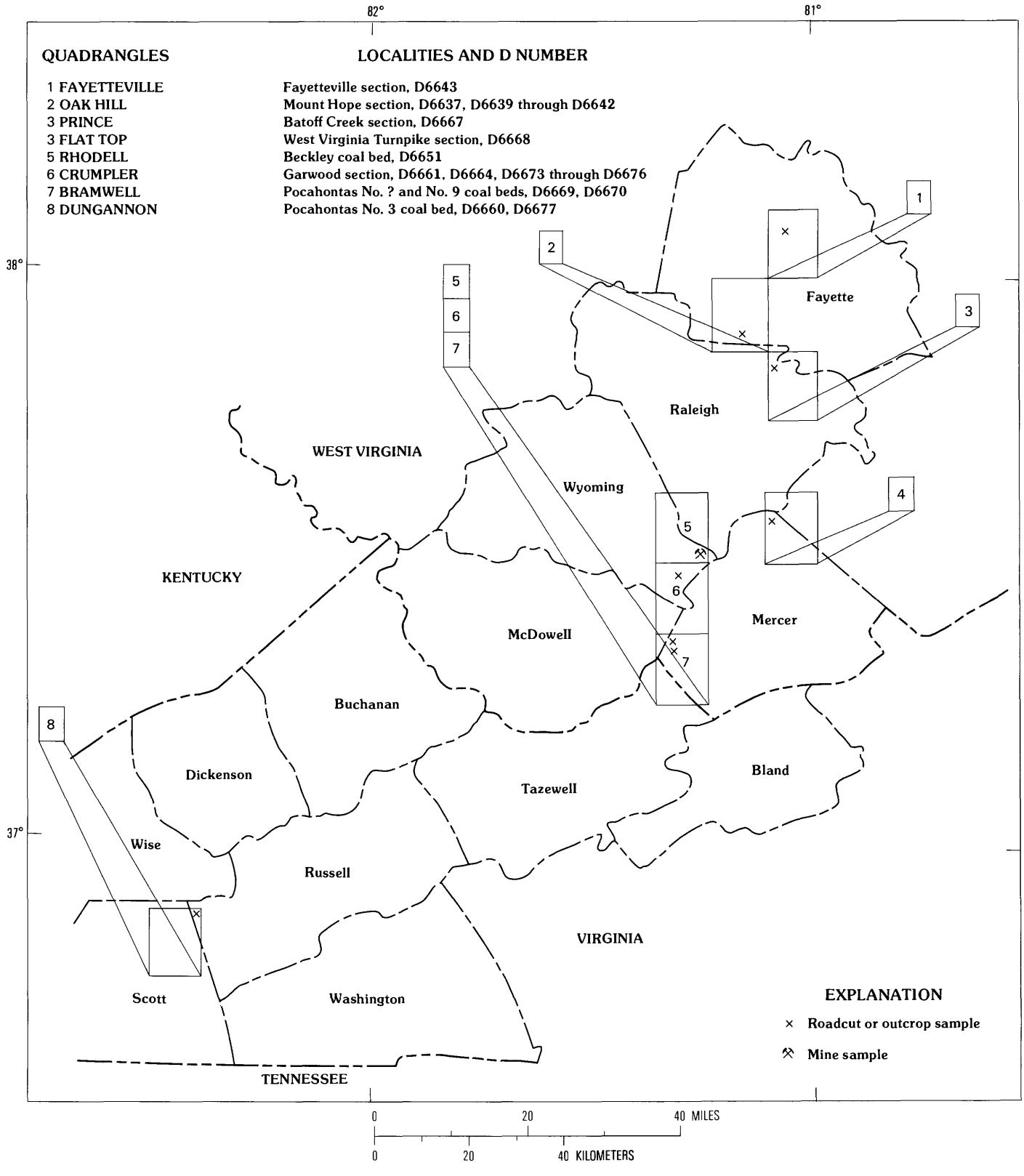

FIGURE 1.—Map of part of Virginia and West Virginia showing roadcut, outcrop, or mine samples used in this investigation. The named sections of Englund, K.J., Arndt, H.H., and Henry, T.W. (1979) and the USGS Paleobotanical locality D numbers are given.

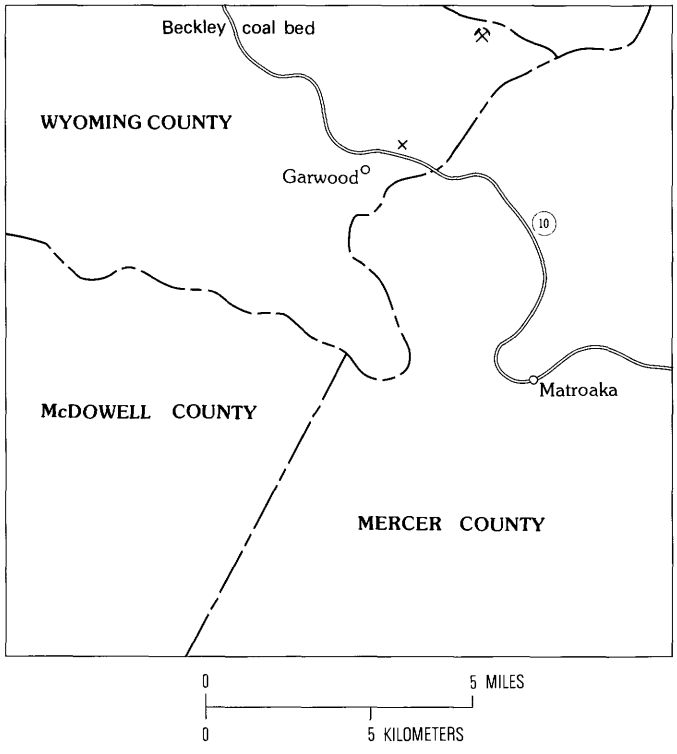

FIGURE 2.—Map showing location of Garwood section and the Beckley coal bed adapted from Englund (1979).

Fire Creek coal bed, Batoff Creek section, Stop 5 of Englund and others (1977) just north of creek along road cut 76 m east of west edge of Prince 7½ minute quadrangle, Raleigh County, West Virginia. This location is shown on figures 1 and 3, D6667, macerations 729A-F.

Beckley coal bed, Stop 10 of Englund (1979), and Englund, Pfefferkorn, and Henry (1979), Kitchekan Fuel Corporation, Matoka Mining Company, Inc., 12-A Mine, Rhodell 7½ minute quadrangle, Wyoming County, West Virginia. The location of this mine is shown on figures 1 and 2, D6651, macerations 740A-F.

Little Raleigh coal bed, Fayetteville section, Stop 12 of Englund and Arndt (1979) and Arndt and others (1979) on the east side of New River Bridge south of U.S. 19, Fayettevile 7½ minute quadrangle, Fayette County, West Virginia. This location is shown on figures 1 and 3, D6643, macerations 728A-C.

Sewell B coal bed, Mount Hope section, Stop 11 of Englund and Arndt (1979) and Arndt and others (1979) located near the Mount Hope exit of U.S. 19, Oak Hill 7½ minute quadrangle, Fayette quadrangle, West Virginia. This location is shown on figures 1 and 3, D6637, macerations 727A-C.

Hughes Ferry coal bed collected from Mount Hope section, same locality as preceding sample, D6642, macerations 726A-C.

Unnamed coal bed within Nuttall Sandstone Member, lower bench, Mount Hope section, same locality as preceding sample, D6641, macerations 725A-C.

Unnamed coal bed within Nuttall Sandstone Member, upper bench, Mount Hope section, same locality as preceding sample, D6640, macerations 724A-D.

Unnamed coal bed within the Nuttall Sandstone Member, Mount Hope section, same locality as preceding sample, D6639, macerations 723A-C.

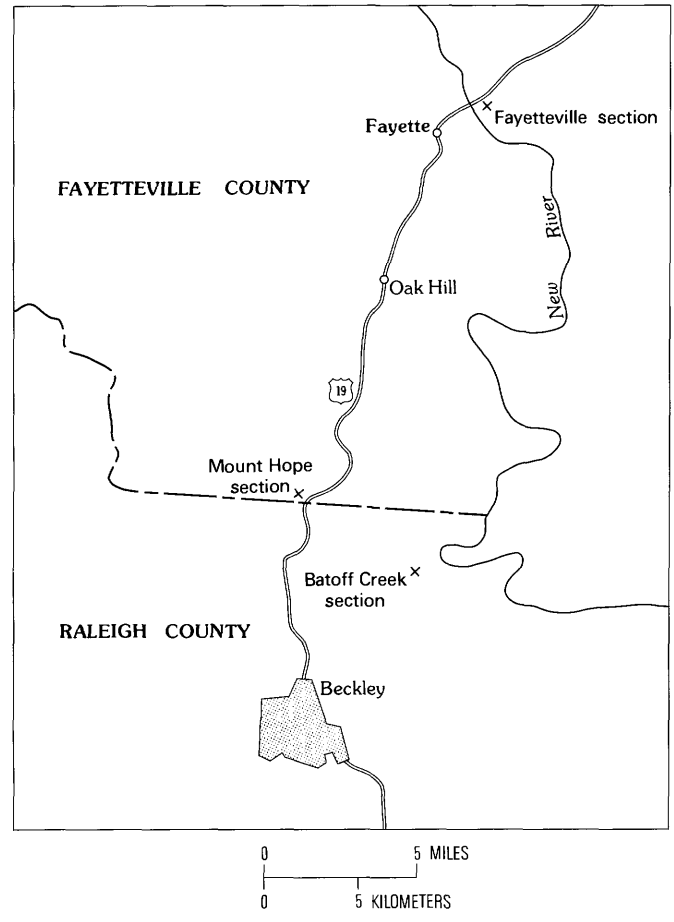

FIGURE 3.—Map showing location of Batoff Creek, Mount Hope, and Fayetteville sections adapted from Englund and Arndt (1979).

UPPER MISSISSIPPIAN SERIES

The Bramwell Member of the Bluestone Formation, the youngest member of Mississippian age, is composed largely of gray, calcareous siltstone and has a black shale bed (Englund and others, 1977). The Mississippian-Pennsylvanian boundary, by definition, is placed between the Bluestone and Pocahontas Formations. A series of samples through the Bramwell Member was collected from the West Virginia Turnpike section, Stop 10 of Englund and others (1976). It was hoped that a comparison could be made between the palynomorphs extracted from the Bramwell Member and the interesting assemblage reported from the Grove Church Formation of Illinois by Winslow (1959) and Kosanke and Peppers (1981). However, this comparison was impossible because of the poor recovery of palynomorphs from the Bramwell Member. The high calcium carbonate content of the Bramwell Member may account for the poor preservation and recovery of palynomorphs. Only three

samples from the Bramwell Member contained palynomorphs (see table 1). The taxa cannot be identified to the specific level and the two genera are not stratigraphically important.

LOWER PENNSYLVANIAN SERIES

The Lower Pennsylvanian Series of the proposed Pennsylvanian System stratotype is composed of the Pocahontas and New River Formations as shown on figure 4. According to Englund in Englund and others (1977), the Pocahontas Formation is a wedge that thins toward the northwest and has a maximum thickness of about 229 m (750 ft). This formation contains a number of coal beds and interbedded sandstone, siltstone, shale, and underclay. The New River Formation overlies the Pocahontas Formation and is about 244 m (800 ft) thick (Englund and others, 1977). The New River Formation contains a number of coal beds, sandstone, siltstone, shale, and underclay and is similar to the Pocahontas Formation except for the presence of thicker quartz-pebble conglomerates and quartzose sandstones. There are three prominent named sandstone members in the New River Formation: the Pineville Sandstone Member above the Pocahontas No. 9 coal bed and below the Little Fire Creek coal bed, the Raleigh Sandstone Member above the Beckley coal bed, and the Nuttall Sandstone Member at the top of the New River Formation.

In a previous investigation, Kosanke (1984) reported that palynomorphs were recovered from several Lower Pennsylvanian samples which included non-coal samples of both the Pocahontas and New River Formations and coal samples from the Sewell coal bed of the New River Formation.

POCAHONTAS FORMATION

The coal beds of the Pocahontas Formation are shown in figure 4. The interval below the Pocahontas No. 1 coal bed and above the tongue of the Bluestone Formation contains thin unnamed coal beds. Two coal beds and adjacent seat and roof rock samples from the Garwood section were collected and assigned to maceration series 699 and 701. The few palynomorphs identified in maceration series 699 and 701 are shown in table 2. One of these beds, maceration 701-B, is the only coal bed in the Pocahontas Formation from which palynomorphs were recovered. The stratigraphic position of maceration 701 is shown in figure 4.

The high degree of thermal alteration of organic matter in both macerations is evidenced by the large amount of opaque matter. The amount of amorphous organic matter and palynomorphs is small. The organic matter is dark brown. Thin walled palynomorphs such as *Lycospora* are transparent but definitely brownish, and thicker walled palynomorphs are darker brown to opaque. The specimen shown on plate 1, figure 11 is *Densosporites* cf. *D. covensis* Berry. Its central body is thin and translucent although the cingulum is essentially opaque. Bleaching with sodium hypochlorite does somewhat lighten thinner walled palynomorphs.

Sets of samples from the following units were barren of palynomorphs: Pocahontas Nos. 2, 3A, the Goodwill coal bed, unit 145 of the Garwood section, and a set of samples of the Beckley coal bed collected near the 12-A mine of the Matoka Mining Company located in Rhodell quadrangle, Wyoming County, West Virginia.

The Pocahontas No. 1 coal bed, maceration series 703, contains abundant fragments of fusinite and a small amount of more or less very dark brown amorphous organic matter. Ovoid, essentially opaque objects are suggestive of palynomorphs.

Two sets of samples of the Pocahontas No. 3 coal bed were collected from Dungannon quadrangle, Virginia. Palynomorph preservation is poor and palynomorphs were extracted only from the roof samples of each of these sets of samples. The first of these two sets of

TABLE 1.—*Palynomorphs from the Bramwell Member of the Bluestone Formation, West Virginia*

[Maceration series 742; USGS Paleobotanical loc. No. D6668; X indicates presence of taxon]

Taxon	742-A	742-B	742-C
Granulatisporites sp.	---	---	X
Lycospora spp.	---	X	X
Unassigned	X	X	X

DESCRIPTION OF MATERIAL IN MACERATIONS

742-A, 7.6 cm shale-siltstone, calcareous
742-B, 7.6 cm 1.5 m below top, shale-siltstone, calcareous
742-C, 7.6 cm 1.5 m below 742-B, shale-siltstone, calcareous
742-D, 7.6 cm 1.5 m below 742-C, shale-siltstone, calcareous
742-E, 7.4 cm 1.5 m below 742-D, shale-siltstone, calcareous
742-F, 7.4 cm basal black shale unit, calcareous

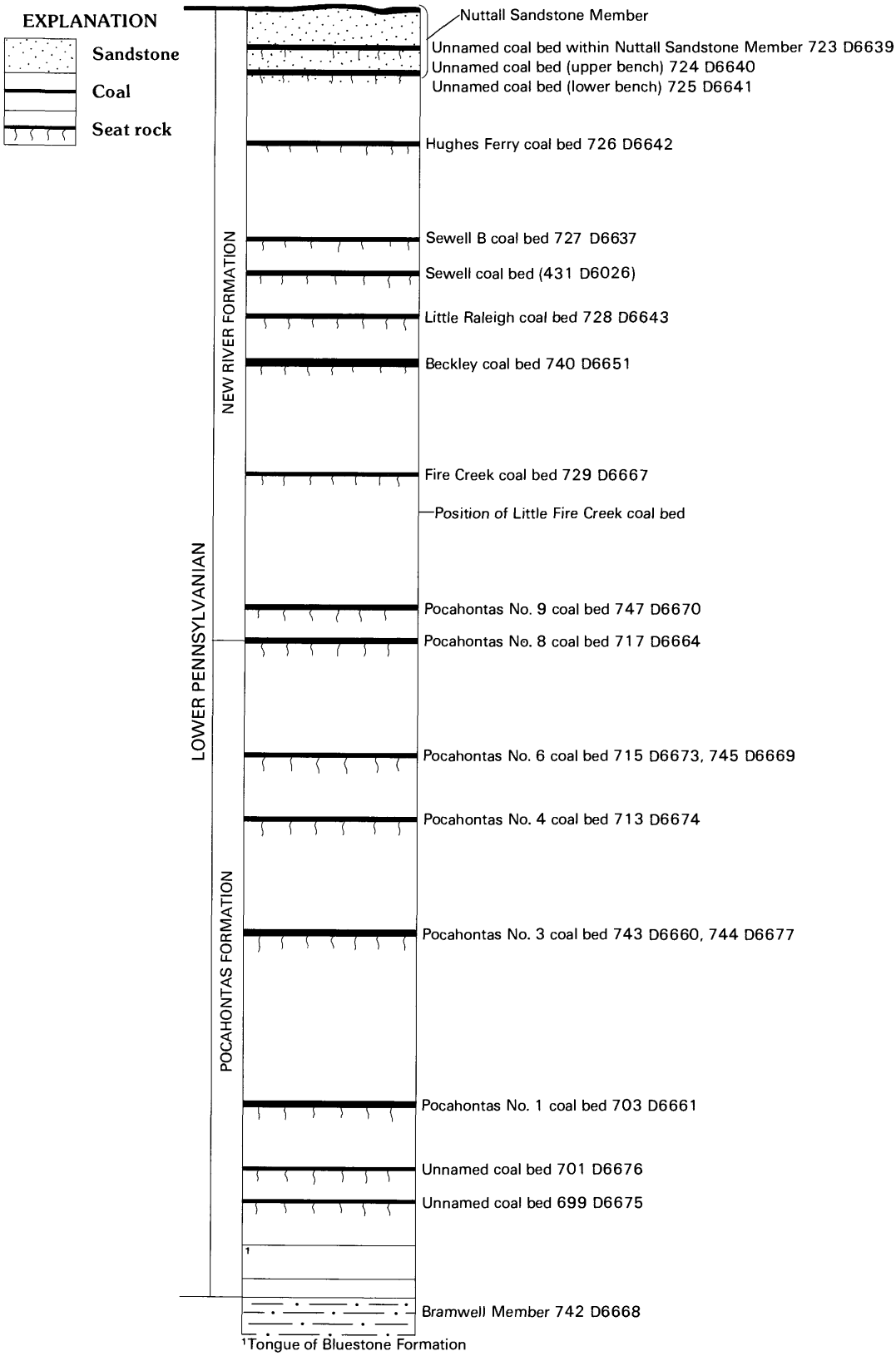

FIGURE 4.—Productive stratigraphic units in the Lower Pennsylvanian Pocahontas and New River Formations that were sampled; samples were examined for palynomorphs. Maceration numbers and D numbers are given for each of the units sampled. The parentheses around these numbers after the Sewell coal bed indicates this information was published in Kosanke (1984).

TABLE 2.—*Palynomorphs from two unnamed coal beds below the Pocahontas No. 1 coal bed, West Virginia*

[Maceration series 699 and 701, USGS Paleobotanical loc. Nos. D6675 and D6676; X indicates presence of taxon]

Taxon	699-A	699-D	701-A	701-B
Convolutispora sp.	X	---	---	---
Crassispora sp.	---	---	---	X
Densosporites cf. D. covensis Berry	---	X	---	---
Densosporites spp.	---	---	X	---
Lycospora noctuina Butterworth and Williams	---	---	X	---
L. pellucida (Wicher) Schopf, Wilson, and Bentall--L. pseudoannulata Kosanke[1]	---	---	X	X
L. spp.	X	X	X	X

[1]In many instances it is not possible to separate these taxa due to poor preservation.

DESCRIPTION OF MATERIAL IN MACERATIONS

699-A, 7.6 cm roof rock, black shale
699-B, 10.1 cm black shale (barren of palynomorphs)
699-C, 4.4 cm coal gradational to seat below (barren of palynomorphs)
699-D, 8.8 cm seat rock

701-A, 10.1 cm roof rock
701-B, 3.8 cm coal
701-C, 8.8 cm seat rock (barren of palynomorphs)

samples, maceration 743, was collected from a railroad spur 1,463 m south of the north line of Dungannon quadrangle and 1,600 m west of the east line of Dungannon quadrangle in Russell County. Palynomorphs were not abundant and opaque attrital material is abundant in the residue. Organic matter is dark brown and the thicker walled palynomorphs are orange-yellow to light brown. Several large unassigned monosaccate taxa are yellow-orange.

The second set of samples, maceration series 744, was collected from a road-cut along Virginia Route 63, close to preceding samples (D6660, macerations 743A-D), Dungannon quadrangle, Russell County, Virginia. Palynomorphs were more abundant than in maceration 743-A, and thermal alteration was more advanced. There are many specimens of *Densosporites* "rings" in which the cingulum is translucent but is dark brown to almost black. A number of translucent brown specimens of *Savitrisporites nux* are present, and specimens of *Lycospora* are a dirty gray-brown color although the equatorial structure is much lighter in color. The palynomorphs identified in these samples are given in table 3.

Two samples of the Pocahontas No. 4 coal bed, units 78 and 79, Garwood section, Stop 9 of Englund (1979) and Englund, Pfefferkorn, and Henry (1979) were collected north of State Route 10, Crumpler 7½ minute quadrangle, Wyoming County, West Virginia. This location is shown on figures 1 and 2, D6674, macerations 713A-B. Maceration 713-A, 6.35 cm of a coaly carbonaceous shale, yielded a limited number of poorly preserved palynomorphs. *Lycospora* is most abundant followed by *Densosporites*. In addition, a few specimens of what appeared to be assignable to *Punctatisporites*, *Lophotriletes*, and *Granulatisporites* were observed. Maceration 713-B, 11.43 cm of medium dark gray seat rock, was barren of palynomorphs.

A set of samples of the Pocahontas No. 6 coal bed was collected from a road cut in Bramwell quadrangle 1,175 m south of the north line of the quadrangle and 3,333 m east of the west line of Mercer County, West Virginia. These samples were assigned to maceration series 745; only the roof shale, maceration 745-A, released palynomorphs. Specimens of *Lycospora* were a translucent dirty brown color although the equatorial structure was a much lighter color. Many dark brown to black *Densosporites* "rings" were observed although the periphery of the cingulum in some specimens, presumably those species with a tapering cingulum, was a very light brown. The residue contained an abundance of fusinite. The palynomorphs recovered are listed in table 4. This is not an extensive assemblage, but *Densosporites irregularis*, *Lycospora noctuina*, and *Waltzispora* sp. all are typical of the Lower Pennsylvanian section. In addition, several fragments of septate hyphae were observed as well as a number of other fungal cells.

A shale sample with plant fossils, maceration 715, was

TABLE 3.—*Palynomorphs from two sets of samples of the Pocahontas No. 3 coal bed, Virginia*

[Macerations series 743 and 744, USGS Paleobotanical loc. Nos. D6660 and D6677; X indicates presence of taxon]

Taxon	743-A	744-A
Ahrensisporites querickei (Horst) Potonié and Kremp	---	X
Calamospora sp.	X	---
Camptotriletes sp.	---	X
Convolutispora varicosa Butterworth and Williams	---	X
C. sp.	X	---
Denososporites irregularis Hacquebard and Barss	---	X
D. spherotriangularis Kosanke	---	X
D. spp.	---	X
Endosporites cf. E. globiformis (Ibrahim) Schopf, Wilson, and Bentall	X	---
Florinites spp.	X	---
Granulatisporites sp.	---	X
Grumosporites sp.	---	X
Knoxisporites sp.	---	X
Leiotriletes sp.	---	X
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	X
L. sp.	---	X
Punctatisporites sinuatus (Artüz) Neves	---	X
P. spp.	X	X
Raistrickia sp.	X	---
Remysporites(?)	X	---
Reticulatisporites sp.	X	---
Savitrisporites nux (Butterworth and Williams) Smith and Butterworth	---	X
Monosaccate	X	---
Unassigned	X	X
Fungal cells	X	---

DESCRIPTION OF MATERIALS IN MACERATIONS

743-A, 10.1 cm roof rock
743-B, 30.4 cm coal (barren of palynomorphs)
743-C, 30.4 cm coal (barren of palynomorphs)
743-D, 10.1 cm seat rock (barren of palynomorphs)

744-A, 19.0 cm roof rock
744-B, 27.9 cm coal (barren of palynomorphs)
744-C, 27.9 cm coal (barren of palynomorphs)

collected from the Garwood section of Englund (1979) and Englund, Pfefferkorn, and Henry (1979) in the Pocahontas No. 6 coal bed horizon. The residue contained a large amount of fragmented orange-reddish brown organic matter and woody fragments that could be classified as semifusinite and fusinite. The palynomorphs were brownish; numerous *Densosporites* "rings" were generally darker translucent brown. Several specimens of *Granulatisporites* were identified as well as many specimens of *Lycospora pellucida* and one specimen identified as *Densosporites* cf. *D. sphaerotriangularis*. The fungi are well represented by a number of different cell types.

NEW RIVER FORMATION

The Pocahontas No. 8 coal bed is the basal unit of the New River Formation. Samples of this bed were collected from the Garwood section of Englund (1979) and Englund, Pfefferkorn, and Henry (1979). Of these samples, maceration series 717, only the non-coal

TABLE 4.—*Palynomorphs from the Pocahontas No. 6 coal bed, West Virginia*

[Maceration series 745, USGS Paleobotanical loc. No. D6669; X indicates presence of taxon]

Taxon	745-A
Ahrensisporites sp.	X
Cyclogranisporites sp.	X
Densosporites irregularis Hacquebard and Barss	X
D. cf. D. sphaerotriangularis Kosanke	X
D. spp.	X
Granulatisporites granulatus Ibrahim	X
Lophotriletes sp.	X
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall--L. pseudoannulata Kosanke	X
L. noctuina Butterworth and Williams	X
L. pellucida (Wicher) Schopf, Wilson, and Bentall	X
Triquitrites sp.	X
Waltzispora sp.	X
Septate fungal hyphae	X
Fungal cells	X

DESCRIPTION OF MATERIAL IN MACERATIONS

745-A, 7.6 cm roof rock
745-B, 6.3 cm roof, black shale (barren of palynomorphs)
745-C, 30.4 cm coal (barren of palynomorphs)
745-D, 10.1 cm seat rock (barren of palynomorphs)

samples yielded palynomorphs, which are translucent brown. *Lycospora* and *Densosporites* are the most abundant palynomorphs. A number of specimens of *Lycospora* are dirty brown although they have a much lighter equatorial structure. The body of *Densosporites irregularis* is a dirty brown and that part of the cingulum adjacent to the body is brown to black. The periphery of the cingulum is a translucent brown. Abundant finely divided organic matter is translucent brown.

A set of samples of the Pocahontas No. 9 coal bed was collected from a road cut located 1,717.8 m south of the north line of Bramwell 7½ minute quadrangle and 3,124 m east of the west line of Bramwell 7½ minute quadrangle, Mercer County, West Virginia, D6670, macerations 747A-F. The Pocahontas No. 9 coal bed occurs a short distance above the Pocahontas No. 8 coal bed (fig. 4) and below the Pineville Sandstone Member; it is the highest coal bed exposed nearby at Pocahontas, Tazwell County, Virginia. The samples of the Pocahontas No. 9 coal bed contain a large amount of fragmented brown organic debris. *Lycospora* is very abundant in the non-coal samples of this maceration series. Most palynomorphs are brownish as in the 717 maceration series, and the periphery of *Lycospora* and *Densosporites* specimens is lighter in color than is the body of the spores. Palynomorphs are much more abundant in these two coal beds than in any other beds samples from the Pocahontas Formation. Table 5 records the palynomorphs present in these two coal beds.

In the stratotype three named coal beds are present between the Pineville Sandstone Member and the Raleigh Sandstone Member. In ascending order these beds are the Little Fire Creek, Fire Creek, and the Beckley. Samples were obtained from the Fire Creek and Beckley coal beds. The Fire Creek samples were assigned to maceration series 729, and the Beckley samples were assigned to maceration series 740. Palynomorphs were recovered from five of the nine segment samples (see table 6), and four of the five productive segment samples are non-coal samples. The thermal alteration of the palynomorphs is not changed greatly from that of the Pocahontas No. 8 and 9 samples. The most common taxon of the Fire Creek coal bed is *Densosporites*; the dominant taxon recovered from the non-coal samples of the Beckley coal bed is *Lycospora*. The residue of the Fire Creek coal bed contains abundant fine opaque matter and fusinite fragments.

The Little Raleigh coal bed occurs between benches of the Raleigh Sandstone Member. A set of samples of this coal bed, maceration series 728, was collected from the Mount Hope section of Arndt and others (1979). Palynomorph recovery from the Little Raleigh coal samples was limited; only five genera were identified in non-coal samples. However, some interesting fungal cells were recovered form the roof rock sample as shown on plate 2, figure 9. Also, what appears to be a scale was recovered from this maceration and is shown on plate 2, figure 10.

TABLE 5.—*Palynomorphs from the Pocahontas Nos. 8 and 9 coal beds, West Virginia*

[Maceration series 717 and 747, USGS Paleobotanical Nos. D6664 and D6670; X indicates presence of taxon]

Taxon	717-A	717-C	747-C	747-D	747-F
Cristatisporites indignabundus (Loose) Staplin and Jansonius	---	X	---	---	---
Crassispora kosankei (Potonié and Kremp) Bharadwaj	---	X	---	---	---
Densosporites annulatus (Loose) Schopf, Wilson, and Bentall	---	X	---	---	---
D. irregularis Hacquebard and Barss	---	X	---	---	---
D. spp	---	X	---	---	---
Dictyotriletes cf. *D. castaneaeformis* (Horst) Sullivan	---	---	---	X	---
Granulatisporites pallidus Kosanke	---	---	---	X	---
Granulatisporites spp	---	X	---	X	---
Knoxisporites sp	---	X	---	---	---
Lophotriletes sp	---	X	---	X	---
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	X	---	---	X
L. noctuina Butterworth and Williams	---	X	---	---	X
L. pellucida (Wicher) Schopf, Wilson, and Bentall *L.*--*pseudoannulata* Kosanke	X	X	X	X	X
L. spp	X	X	X	X	X
Procoronaspora(?)	---	---	---	---	X
Schulzospora rara Kosanke	---	---	---	---	X
Waltzispora cf. *W. polita* (Hoffmeister, Staplin, and Malloy) Smith and Butterworth	---	---	---	---	X
W. sp	X	---	---	---	---

DESCRIPTION OF MATERIAL IN MACERATIONS

717-A, 10.1 cm roof rock, silty
717-B, 6.9 cm coal
717-C, 8.8 cm seat rock, silty

747-A, 5.0 cm coal, vitrinite (barren of palynomorphs)
747-B, 16.5 cm clay-shale (barren of palynomorphs)
747-C, 8.8 cm shale, black, coaly
747-D, 20.3 cm shale, gray
747-E, 21.5 cm coal (barren of palynomorphs)
747-F, 7.6 cm seat rock

Kosanke (1984) recovered palynomorphs from both non-coal and coal samples of the Sewell coal bed (maceration series 431). The coal samples were weathered which may have facilitated palynomorph extraction. Although it was not realized at the time, these palynomorphs from the Sewell coal bed are the oldest palynomorphs of stratigraphic value extracted from stratotype coals.

Palynomorphs can usually be extracted from all younger coal beds of the stratotype. It should be noted that a few poorly preserved palynomorphs were extracted from an unnamed coal bed occurring below the Pocahontas No. 1 coal bed (maceration series 701) in the lower part of the Pocahontas Formation. However, it should also be noted that thermal alteration of palynomorphs extracted fom the Sewell coal bed (Kosanke, 1984) was definitely less than for those of the unnamed coal bed of maceration series 701. The basis for this statement is the fact that the cingulum of *Densosporites* is brown but is translucent.

Samples of the Sewell B coal bed (maceration series 727) were collected from the Mount Hope section of Arndt and others (1979) as were the preceding samples of the Little Raleigh coal bed. Fourteen genera were identified from the Sewell B coal bed and adjacent strata. Although palynomorphs were recovered from the coal samples, the best recovery is from the seat rock sample, 727-D. In this sample *Reticulatisporites* cf. *R. reticulatus* (Ibrahim) Ibrahim is present. This taxon occurs in Europe, according to Smith and Butterworth

TABLE 6.—*Palynomorphs from the Fire Creek and Beckley coal beds, West Virginia*

[Maceration series 729 and 740; USGS Paleobotanical loc. Nos. D6667 and D6651; X indicates presence of taxon]

Taxon	729-A	729-B	740-A	740-C	740-F
Calamospora cf. C. hartungiana Schopf, Wilson, and Bentall	---	---	---	---	X
Convolutispora sp.	X	---	---	---	---
Crassispora kosankei (Potonié and Kremp) Bharadwaj	---	---	---	---	X
Densosporites covensis Berry	X	---	---	---	---
D. sphaerotriangularis Kosanke	X	---	---	---	---
D. spp.	X	---	---	X	---
Granulatisporites pallidus Kosanke	X	---	---	---	---
G. spp.	X	---	---	---	X
Lophotriletes sp.	X	---	---	---	---
Lycospora granulata Kosanke	---	---	X	---	---
L. micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	---	X	X	X
L. noctuina Butterworth and Williams	---	---	X	---	---
L. pellucida (Wicher) Schopf, Wilson, and Bentall L. pseudoannulata Kosanke	---	---	X	X	X
L. spp.	X	---	X	X	X
Microreticulatisporites sp.	---	---	---	---	X
Procoronaspora sp.	---	---	---	---	X
Punctatisporites sp.	---	---	---	X	---
Schulzospora rara Kosanke	---	---	---	X	---
Vestispora sp.	---	X	---	---	---
Waltzispora prisca (Kosanke) Sullivan	---	---	---	X	---
W. sp.	---	---	X	---	---
Unassigned	X	---	---	---	---

DESCRIPTION OF MATERIAL IN MACERATIONS

729-A, 5.0 cm roof rock
729-B, 34.2 cm coal
729-C, 10.1 cm seat rock (barren of palynomorphs)

740-A, 7.6 cm roof rock
740-B, 20.3 cm coal, cleated (barren of palynomorphs)
740-C, 20.9 cm parting
740-D, 30.4 cm coal (barren of palynomorphs)
740-E, 30.4 cm coal (barren of palynomorphs)
740-F, 5.0 cm seat rock

(1967), from Westphalian A through D. This suggests the upper part of the New River Formation could be equivalent to the Westphalian A of Europe. The effects of thermal alteration on thin- and thick-walled palynomorphs are demonstrated by palynomorphs from this seat rock sample (727-D). Lycospora is thin walled; *Savitrisporites* is basically thick walled because of its prominent heavy ridges. *Lycospora* is brown but very translucent; *Savitrisporites* is very dark brown to opaque though occasionally a lighter translucent brown can be seen between the thick ridges that form the ornamentation. The palynomorphs identified from the samples of the Sewell B coal bed are shown on table 7.

The Hughes Ferry coal bed was sampled at an outcrop at the former site of Hughes Ferry on Gauley River, Fayette County, West Virginia. The samples of this coal bed (maceration series 726) were collected at Stop 11 of Arndt and others (1979), the Mount Hope section (see figures 1 and 3). Palynomorphs were recovered from all samples, 726A-C; however, the best recovery was from the seat rock sample, 726-C. Recovery from the roof rock sample (726-A) and the coal (726-B) is not extensive as can be seen from table 8. The palynomorphs are brown but translucent and this applies even to the cingulum of *Densosporites*. This translucency is difficult to demonstrate in black and white photomicrographs as may be seen on plate 1, figure 10. I judge that the specimens in this maceration are lighter in color than those from older coal beds previously discussed. The palynomorphs

TABLE 7.—*Palynomorphs from the Little Raleigh and Sewell B coal beds, West Virginia*

[Maceration series 728 and 727; USGS Paleobotanical loc. Nos. D6643 and 6637; X indicates presence of taxon]

Taxon	728-A	728-C	727-A	727-B	727-C	727-D
Calamospora mutabilis (Loose) Schopf, Wilson and Bentall	---	---	---	---	---	X
Cirratriradites saturni (Ibrahim) Schopf, Wilson, and Bentall	---	---	---	---	---	X
Crassispora kosankei (Potonié and Kremp) Bharadwaj	---	---	---	X	X	X
Cristatisporites indignabundus (Loose) Staplin and Jansonius	---	---	---	---	X	---
Densosporites spp	---	X	---	---	---	---
Dictyotriletes sp	---	---	---	---	---	X
Granulatisporites granulatus Ibrahim	X	---	---	X	---	X
Leiotriletes priddyi (Berry) Potonié and Kremp	---	---	---	---	---	X
Lycospora granulata Kosanke	X	X	X	X	---	X
L. micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	X	---	---	---	---
L. pellucida (Wicher) Schopf, Wilson, and Bentall--L. pseudoannulata Kosanke	---	X	X	X	---	X
L. cf. L. punctata Kosanke	---	---	---	X	---	X
L. spp	X	X	X	X	X	X
Punctatisporites sp	X	X	---	X	---	X
Raistrickia sp	---	---	---	---	---	X
Reticulatisporites cf. R. reticulatus (Ibrahim) Ibrahim	---	---	---	---	---	X
Savitrisporites nux (Butterworth and Williams) Smith and Butterworth	---	---	---	---	---	X
Verrucosisporites sp	---	---	---	---	---	X
Waltzispora sp	X	---	---	---	---	---
Unassigned	---	---	---	X	---	---
Fungal cells	X	---	---	---	---	---
Scale(?)	X	---	---	---	---	---

DESCRIPTION OF MATERIAL IN MACERATIONS

728-A, 10.1 cm roof rock
728-B, 38.1 cm coal (barren of palynomorphs)
728-C, 11.4 cm seat rock

727-A, 10.1 cm shale
727-B, 10.1 black shale with vitrinite
727-C, 27.9 cm coal
727-D, 10.1 cm seat rock

identified from the Hughes Ferry coal bed are shown in table 8.

At the Mount Hope section, two unnamed coal beds lie very near the top of the New River Formation of the stratotype. The lower of these beds occurs within the base of the Nuttall Sandstone Member and is divided into lower and upper benches. The upper coal bed occurs a short distance above the first coal bed. Because a seat rock occurs beneath both benches of the lower coal, separate maceration numbers were applied to these samples. The palynomorphs of the lower bench, maceration series 725, are brown and translucent. There is a great deal of organic matter in the seat rock sample and I judge that the palynomorphs are slightly darker than those of the Hughes Ferry coal bed. The darker color could be accounted for by weathering or differences in preparation time required to release the botanic ingredients.

Although palynomorphs were not recovered from the coal samples (725-B), I consider the presence of *Laevigatosporites* in the seat rock sample (725-C) very important, because this is the first unquestioned

TABLE 8.—*Palynomorphs from the Hughes Ferry coal bed and from the lower bench of an unnamed coal bed at the base of the Nuttall Sandstone Member, West Virginia*

[Maceration series 726 and 725, USGS Paleobotanical loc. Nos. D6642 and D6641; X indicates presence of taxon]

Taxon	726-A	726-B	726-C	725-A	725-C
Apiculatisporis sp.	---	---	X	---	X
Calamospora mutabilis (Loose) Schopf, Wilson and Bentall	---	---	X	---	---
Cristatisporites indignabundus (Loose) Staplin and Jansonius	---	---	X	---	---
Cyclogranisporites sp.	---	---	---	---	X
Densosporites annulatus (Loose) Schopf, Wilson, and Bentall	---	---	---	X	---
D. irregularis Hacquebard and Barss	---	---	X	---	---
D. sp.	X	---	X	X	---
Dictyotriletes sp.	---	---	---	X	X
Granulatisporites sp.	---	---	X	---	---
Knoxisporites sp.	---	---	---	X	---
Laevigatosporites sp. 1	---	---	---	---	X
Leiotriletes sp.	---	---	---	---	X
Lycospora granulata Kosanke	---	X	---	---	---
L. micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	---	X	---	X
L. noctuina Butterworth and Williams	---	---	X	---	X
L. pellucida (Wicher) Schopf, Wilson, and Bentall L. pseudoannulata Kosanke	X	X	X	X	X
L. punctata Kosanke	X	---	X	X	X
L. spp.	X	X	X	X	X
Punctatisporites spp.	---	X	X	---	X
Monosaccate	---	---	X	---	---

DESCRIPTION OF MATERIAL IN MACERATIONS

726-A, 10.1 cm roof rock
726-B, 30.4 cm coal
726-C, 10.1 cm seat rock

725-A, 10.1 cm roof rock
725-B, 30.4 cm coal (barren of palynomorphs)
725-C, 10.1 cm seat rock

occurrence of this genus in the Lower Pennsylvanian Series of the stratotype. Kosanke (1984) found two folded specimens in the Sewell coal bed (maceration 431-C) that might be related to *Laevigatosporites*, but no specimens of this genus were found in coal beds between the Sewell and these unnamed coal beds. In Ohio, *Laevigatosporites* was not found in samples of the Sharon No. 1 or Anthony coal beds, but the genus was well represented in the Quakertown No. 2 coal bed above the Anthony coal bed (Kosanke, 1984). In Sawyer quadrangle, Kentucky, *Laevigatosporites* was not found in an unnamed coal bed just above the Mississippian-Pennsylvanian boundary or in the Hudson, Stearns 1½, and Beaver Creek coal beds above this unnamed coal bed (Kosanke, 1984). Kosanke (1984) reported the first Pennsylvanian occurrence of *Laevigatosporites* in Kentucky to be in the Barren Fork coal bed above the Beaver Creek coal bed. In Illinois, *Laevigatosporites* was not found in a series of thin coal beds in the lower part of the Caseyville Formation (Kosanke, 1982). Kosanke (1950) reported the first Pennsylvanian occurrence of the genus in the Reynoldsburg coal which is now considered to be the basal part of the Abbott Formation according to Hopkins and Simon (1975). In Muscatine County, Iowa, Ravn and Fitzgerald (1982) described palynomorphs from coal beds occurring in Pennsylvanian outliers. They report *Laevigatosporites* present and consider these thin coal beds to be of Morrowan age.

In Oklahoma, Felix and Burbridge (1967) reported *Laevigatosporites* present in the Springer Formation. They found 15 specimens present in seven different shale samples occurring between the Rod Club and Lake Ardmore sandstone members. Thus, the genus is

reported, at least in part, from rocks older than those reported in this paper. Felix and Burbridge assigned their specimens of *Laevigatosporites* to *L. ovalis*. It is possible these specimens, as described and illustrated (p. 406, pl. 61, fig. 8) by Felix and Burbridge, may not be conspecific with *L. ovalis*. The basis for this query is that the width to length ratio is slightly less than 2:3 in the specimens from the Springer Formation whereas in *L. ovalis* this ratio is about 3:4. However, there is no question that the specimens from the Springer Formation are assignable to *Laevigatosporites*.

Kosanke and Peppers (1981), in a preliminary report on the palynomorphs of the Chester coal beds of Illinois, did not report *Laevigatosporites* in these beds. Smith and Butterworth (1967) indicate in text-figure 5 that *Laevigatosporites* is present in the upper part of the Namurian but that there is a gap between the upper part of the Namurian and Westphalian A. Clayton and others (1977) report that in western Europe *Laevigatosporites* has a continuous range upward from the lower part of Westphalian A, but that the genus might occur in older Namurian strata. In the stratotype of Virginia and West Virginia, the genus is consistently present from the upper part of the New River Formation and increases in abundance in the Kanawha Formation and Charleston Sandstone.

Samples from the upper bench of the unnamed coal bed within the Nuttall Sandstone Member from along U.S. 19 at Mount Hope Exit (Arndt and others, figure 14, 1979) were assigned to maceration series 724. The coal bed at this locality is 39.3 cm thick. Although the roof rock (724-A) and the upper coal sample (724-B) did not yield an abundant or diversified assemblage of palynomorphs, the lower coal sample (724-C) yielded more palynomorphs than did any other sample from the Nuttall Sandstone Member. A number of taxa encountered in the 724 maceration series are illustrated in plates 1 and 2. These include the following shown in plate 1: *Punctatisporites sinuatus* (Artüz) Neves, *Lycospora pseudoannulata* Kosanke, *L. noctuina* Butterworth and Williams, and *L. micropapillata* (Wilson and Coe) Schopf, Wilson, and Bentall. *Radiizonates* sp. and *Laevigatosporites* sp. 1 are shown on plate 2. Nine genera are identified in the 724 maceration series and most of these are in 724C-D.

The uppermost coal bed in the New River Formation of the stratotype is the youngest of the unnamed beds in the Nuttall Sandstone Member. This bed was assigned to maceration series 723. Samples of this bed are from the area of the preceding samples, the Mount Hope section of Arndt and others (1979). In the 724 maceration series palynomorphs appeared in coal rather than non-coal samples, and this change persists in the 723 maceration series. As a matter of fact, the best recovery of palynomorphs in the 723 maceration series was from the coal (723-B). The roof rock sample was barren of palynomorphs but contained abundant organic matter. The coal sample contains abundant golden brown organic matter thought possibly to be animal pellicle. A piece of this material is shown on plate 2, figure 11. The palynomorphs of this coal sample are perhaps lighter in color than any others so far discussed in this paper. For example, specimens of *Laevigatosporites* are light brown, those of *Lycospora* are yellowish to light brown, and those of *Densosporites* are translucent even in the cingulum. Taxa from this coal bed that are illustrated on plate 1 are *Verrucosisporites*, *Microreticulatisporites*, *Densosporites*, and *Lycospora*. Taxa from this coal bed that are illustrated on plate 2 are *Cristatisporites* and *Lycospora*. Taxa identified from maceration series 724 and 723 appear in table 9.

A few specimens assignable to *Laevigatosporites* have been observed in this coal and in the seat rock of maceration series 725. These specimens in their overall length, lenth-width ratio, and length of their monolete aperture are similar to *L. ovalis*. However, these specimens cannot be asssigned to *L. ovalis* because their spore coat is not levigate so they have been assigned to species 1 for the present. These specimens have a diffuse irregular punctate ornamentation. In some ways these specimens assigned to L. sp. 1 vaguely resemble *L. latus* or even *L. vulgaris* in overall outline. Ultimately, as more specimens are found, it may be necessary to describe L. sp. 1 as a distinct species. It is a generally accepted view that large species of *Laevigatosporites* are related to the Sphenopsida and the smaller species are related to the Filicales. This observation is based on the careful work of a number of paleobotanists studying Pennsylvanian fructifications.

SUMMARY

From the beginning of this investigation it was realized that recovery of palynomorphs from coal beds of the Pocahontas and New River Formations would be difficult, but that non-coal seat and roof rock samples could yield some palynomorphs. Palynologists have long recognized that palynomorphs are more readily extracted from non-coal samples than from adjacent high rank coal beds. A possible explanation for this fact is discussed by Bostick and Foster (1975). They found vitrinite reflectance lower in shale than in coal of the same stratigraphic sequence which may suggest that palynomorphs in shale are not as adversely effected by thermal activity. This could explain why palynomorph recovery, and perhaps preservation, is better for non-coal samples. In all, 29 sets of samples were collected.

TABLE 9.—*Palynomorphs from two unnamed coal beds, the upper bench of lower coal bed near base of the Nuttall Sandstone Member and another unnamed coal bed above within the Nuttall Sandstone Member, West Virginia*

[Maceration series 724 and 723; USGS Paleobotanical loc. Nos. D6640 and D6639; X indicates presence of taxon]

Taxon	724-A	724-B	724-C	724-D	723-B	723-C
Ahrensisporites cf. A. guerickei (Horst) Potonié and Kremp	X	---	---	---	---	---
Apiculatisporis sp	---	---	X	---	---	---
Calamospora sp	---	---	---	---	---	X
Cristatisporites indignabundus (Loose) Staplin and Jansonius	---	---	---	---	X	---
Densosporites annulatus (Loose) Schopf, Wilson, and Bentall	---	---	X	---	X	---
D. irregularis Hacquebard and Barss	---	---	---	X	---	---
D. sp	X	---	X	---	X	---
Granulatisporites granulatus Ibrahim	---	---	---	---	X	---
Laevigatosporites sp. 1	---	---	X	X	X	---
Lycospora granulata Kosanke	---	---	X	X	X	---
L. micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	---	---	---	X	X	---
L. noctuina Butterworth and Williams	---	---	---	X	---	---
L. cf. L. orbicula (Potonié and Kremp) Smith and Butterworth	---	---	---	X	---	---
L. pellucida (Wicher) Schopf, Wilson, and Bentall L. pseudoannulata Kosanke	---	---	X	X	X	X
L. punctata Kosanke	---	---	---	X	---	---
L. spp	X	---	X	X	X	X
Microreticulatisporites cf. M. concavus Butterworth and Williams	---	---	---	---	X	---
Punctatisporites sinuatus (Artüz) Neves	---	---	X	---	---	---
P. sp	---	---	X	---	---	---
Pustulatisporites sp	---	---	X	---	---	---
Radiizonates sp	---	---	---	X	---	---
Schulzospora sp	---	---	X	---	---	---
Verrucosisporites sp	---	---	---	---	X	---
Unassigned	---	---	X	---	---	---
Animal pellicle	---	---	---	---	X	---

DESCRIPTION OF MATERIAL IN MACERATIONS

724-A, 10.1 cm roof rock
724-B, 19.0 cm coal
724-C, 20.3 cm coal
724-D, 10.1 cm seat rock

723-A, 10.1 cm roof rock (barren of palynomorphs)
723-B, 21.1 cm coal
723-C, 10.1 cm seat rock

These were composed of 112 segment samples. Palynomorphs were recovered from segment samples of 19 of the 29 sample sets.

Recovery of palynomorphs from the Upper Mississippian Bramwell Member of the Bluestone Formation was very poor. Six non-coal samples were collected; of these, three contained only a few non-diagnostic palynomorphs. Of 25 samples of seat rock, coal, and roof rock collected from the Pocahontas Formation, eight non-coal samples and one coal sample contained palynomorphs. Of 29 segment samples from the New River Formation which were examined in detail, 21 contained palynomorphs. Six of these samples were coal. There is no doubt that diversity and quality of palynomorph recovery increases in the upper part of the New River Formation.

It has been possible to trace range zones of several taxa occurring in the Pocahontas and New River

Formations. For example, *Lycospora noctuina* Butterworth and Williams, in western Europe, ranges from the Visean to Westphalian A. This distinctive taxon is present in a number of samples from the Pocahontas and lower New River Formations to at least the Beckley coal bed. *Densosporites irregularis* Hacquebard and Barss is rarely abundant but does occur throughout the Lower Pennsylvanian Series. In this investigation it has been identified in a number of samples. *Schulzospora rara* Kosanke, which is very abundant in Upper Mississippian strata, occurs in limited numbers in Lower Pennsylvanian strata. The range zone of this taxon ends in the lower part of the Middle Pennsylvanian Series. I consider establishing the start of the Pennsylvanian range zone of *Laevigatosporites* very important. Two questionable folded specimens have been found in the Sewell coal bed (Kosanke, 1984). In this study valid specimens of the genus were found near the top of the New River Formation in the Hughes Ferry coal bed and in the unnamed coal beds within the Nuttall Sandstone Member.

Fungal remains were observed in the Pocahontas Nos. 3 and 6 coal beds and the Little Raleigh coal bed. This material in some cases was simply isolated clusters of cells or septate hyphae. What may be animal pellicle was observed in the unnamed coal bed which occurs within the Nuttall Sandstone Member. Also, a scale(?) was observed in the Little Raleigh coal bed.

The palynomorphs and other organic matter observed in this investigation show a high degree of thermal alteration. In general, the samples from the Pocahontas Formation are in the brown-to-black category of Staplin (1977) and thus have a thermal index approaching 4.0. The color of organic matter becomes lighter in stratigraphically younger samples from the New River Formation, and the thermal index of these samples is much lower. There are two points I would like to make. First, the structurally thin parts of palynomorphs such as the equatorial features of *Lycospora* and of some species of *Densosporites* or the body of *Densosporites* are lighter in color than the thicker portions of these palynomorphs. Secondly, generally palynomorphs extracted from older strata are darker brown-black while those from younger strata are lighter brown. However, the correlation between color of palynomorphs and age of strata is not perfect. Perhaps color is, in part, related to local factors.

Wilson (1961) reported, "Spores and other plant microfossils do not occur in the Arkoma Basin of eastern Oklahoma where the fixed carbon is in excess of 70%." It is not possible to make a meaningful comparison of the fixed-carbon content of the weathered coal samples available from the stratotype area with that of fresh coal samples from the Arkoma Basin. In order to do so, unoxidized samples of stratotype coals would be needed.

This investigation has shown that valuable palynomorph data can be obtained from Lower Pennsylvanian strata of the proposed Pennsylvanian System stratotype located in Virginia and West Virginia. In the Pocahontas Formation much of this information comes from non-coal samples adjacent to the coal beds. In the younger New River Formation, both coal and non-coal samples contribute important informaiton. Palynomorph data derived from lower rank coal beds in the same stratigraphic sequence would augment this study.

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PLATES

Contact photographs of the plates in this report are available, at cost,
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PLATE 1

(Slide coordinates established using Leitz Ortholux microscope 569349)

Figure 1. *Punctatisporites sinuatus* (Artüz) Neves, USGS Paleobotanical loc. No. D6640-B, upper bench of unnamed coal bed below the Nuttall Sandstone Member, maceration 724-C, slide 5, coordinates 106.1 × 2.6, negative 4941. The specimen has a maximum diameter of 78.9 microns.

Figure 2. *Waltzispora prisca* (Kosanke) Sullivan, USGS Paleobotanical loc. No. 6651-B, parting in the Beckley coal bed, maceration 749-C, slide 14, coordinates 122.6 × 22.8, negative number 4893. The specimen has a maximum diameter of 34.1 microns.

Figure 3. *Waltzispora* sp., USGS Paleobotanical loc. No. D6664-A, seat rock of the Pocahontas No. 8 coal bed, maceration 717-A, slide 1, coordinates 102.0 × 17.9, negative number 4893. The specimen has a maximum diameter of 35.5 microns.

Figure 4. *Apiculatisporis* sp., USGS Paleobotanical loc. No. D6642-A, the seat rock of the Hughes Ferry coal bed, maceration 726-C, slide 1, coordinates 106.4 × 20.0, negative number 4938. The specimen has a maximum diameter of 44.7 microns.

Figure 5. *Knoxisporites* cf. *K. dissidius* Neves, USGS Paleobotanical loc. No. D6641-A, roof rock of the lower bench of an unnamed coal bed below the Nuttall Sandstone Member, maceration 725-C, slide 1, coordinates 116.6 × 13.4, negative 4929. The specimen has a maximum diameter of 38.1 microns.

Figure 6. *Pileatisporites* (?), USGS Paleobotanical loc. No. D6637-A, coordinates 119.5 × 21.0, negative 4904. The specimen has maximum diameter of 39.4 microns.

Figure 7. *Verrucosisporites* sp., USGS Paleobotanical loc. No. D6639-B, unnamed coal bed in the Nuttall Sandstone Member, maceration 723-B, slide 5, coordinates 110.6 × 6.0, negative number 4918. The specimen has a maximum diameter of 31.5 microns.

Figure 8. *Microreticulatisporites* cf. *M. concavus* Butterworth and Williams, USGS Paleobotanical loc. No. 6639-B, unnamed coal bed in the Nuttall Sandstone Member, maceration 723-B, slide 2, coordinates 116.9 × 6.9, negative number 4919. The maximum diameter of the specimen is 31.5 microns.

Figure 9. *Densosporites* sp., USGS Paleobotanical loc. No. 6639-B, coal bed in the Nuttall Sandstone Member, maceration 723-B, slide 6, coordinates 121.3 × 16.2, negative number 4930. The maximum diameter of the specimen is 44.7 microns.

Figure 10. *D. irregularis* Hacquebard and Barss, USGS Paleobotanical loc. No. 6642-A, seat rock of the Hughes Ferry coal bed, maceration 726-C, slide 1, coordinates 103.4 × 14.0, negative number 4906. The maximum diameter of the specimen is 44.7 microns.

Figure 11. *D.* cf. *D. covensis* Berry, USGS Paleobotanical loc. No. D6675-A, seat rock of an unnamed coal bed below Pocahontas No. 1 coal bed, see figure 2, maceration 699-D, slide 13, coordinates 116.4 × 2.4, negative 4943. The maximum diameter of the specimen is 34.1 microns.

Figure 12. *Lycospora pellucida* (Wicher) Schopf, Wilson, and Bentall, USGS Paleobotanical loc. No. D6651-A, seat rock of the Beckley coal bed, maceration 740-B, slide 3, coordinates 112.9 × 9.0, negative number 4900. The maximum diameter of the specimen is 34.1 microns.

Figure 13. *L. pellucida* (Wicher) Schopf, Wilson, and Bentall, USGS Paleobotanical loc. No. D6651-A, seat rock of the Beckley coal bed, maceration 740-F, slide 1, coordinates 104.7 × 23.7, negative number 4897. The maximum diameter of the specimen is 36.8 microns.

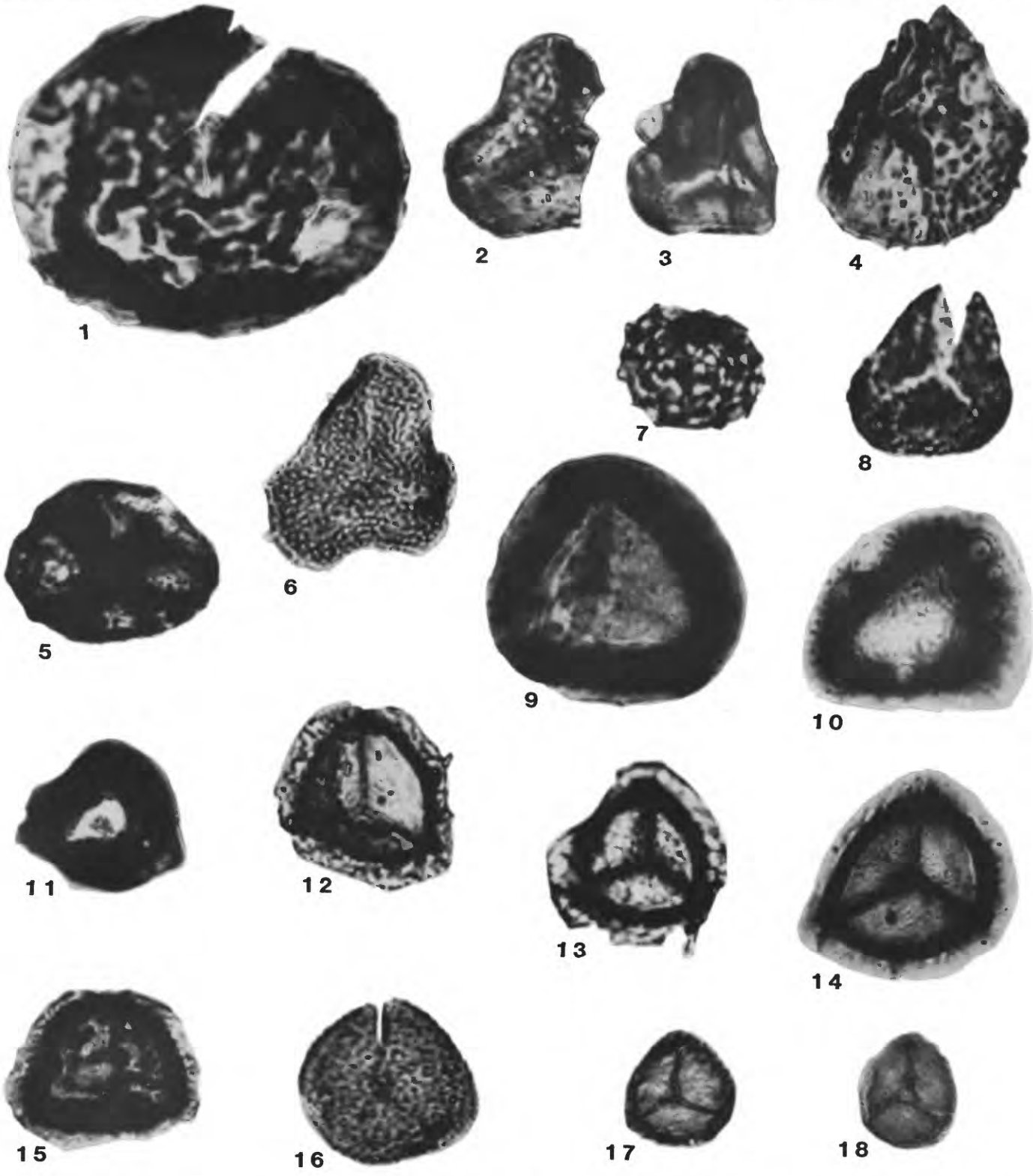
Figure 14. *L. pseudoannulata* Kosanke, USGS Paleobotanical loc. No.D6640-A, seat rock of the upper bench of unnamed coal bed below Nuttall Sandstone Member, maceration 724-D, slide 7, coordinates 115.2 × 11.2, negative number 4908. The specimen has a maximum diameter of 36.8 microns.

Figure 15. *L. noctuina* Butterworth and Williams, USGS Paleobotanical loc. No. D6640-A, seat rock of upper bench of unnamed coal bed below the Nuttall Sandstone Member, maceration 724-D, slide 7, coordinates 102.6 × 7.2, negative number 4910. The specimen has a maximum diameter of 32.8 microns.

Figure 16. *L.* cf. *L. orbicula* (Potonié and Kremp) Smith and Butterworth, USGS Paleobotanical loc. No. 6639-B, unnamed coal bed in the Nuttall Sandstone Member, maceration 723-B, slide 2, coordinates 112.9 × 11.1, negative number 4931. The specimen has a maximum diameter of 32.8 microns.

Figure 17. *L. micropapillata* (Wilson and Coe) Schopf, Wilson, and Bentall, USGS Paleobotanical loc. No. D6640-A, seat rock of upper bench of unnamed coal bed below the Nuttall Sandstone Member, maceration 724-D, slide 1, coordinates 107.6 × 6.9, negative number 4934. The specimen has a maximum diameter of 21.0 microns.

Figure 18. *L. micropapillata* (Wilson and Coe) Schopf, Wilson, and Bentall, USGS Paleobotanical loc. No. D6640-A, seat rock of the upper bench of unnamed coal bed below the Nuttall Sandstone Member, maceration 724-D, slide 7, coordinates 113.8 × 12.1, negative number 4911. Maximum diameter of the specimen is 21.0 microns.



PUNCTATISPORITES, WALTZISPORA, APICULATISPORIS, KNOXISPORITES, PILEATISPORITES, VERRUCOSISPORITES, MICRORETICULATISPORITES, DENSOSPORITES, AND *LYCOSPORA*

PLATE 2

(Slide coordinates established using Leitz Ortholux microscope 569349)

Figure 1. *Cristatisporites indignabundus* (Loose) Staplin and Jansonius, USGS Paleobotanical loc. No. D6639–B, unnamed coal bed in the Nuttall Sandstone Member, maceration 723–B, slide 2, coordinates 109.4 × 18.7, negative number 4932. The specimen has a maximum diameter of 57.8 microns.

Figure 2. Unassigned taxon, USGS Paleobotanical loc. No. D6651–C, roof rock of the Beckley coal bed, maceration 740–A, slide 1, coordinates 106.4 × 20.7, negative number 4894. Maximum diameter of the specimen is 26.3 microns.

Figure 3. Unassigned taxon, USGS Paleobotanical loc. No. D6637–C, roof rock of the Sewell B coal bed, maceration 727–B, slide 1, coordinates 102.3 × 14.0, negative number 4905. The specimen has a maximum diameter of 28.9 microns.

Figure 4. *Schulzospora* cf. *S. rara* Kosanke, USGS Paleobotanical loc. No. D6651–B, parting in the Beckley coal bed, maceration 749–C, slide 8, coordinates 111.7 × 10.3, negative number 4944. Maximum diameter of the specimen is 98.6 microns.

Figure 5. *Radiizonates* sp., USGS Paleobotanical loc. No. D6640–A, seat rock from the upper bench of an unnamed coal bed below the Nuttall Sandstone Member, maceration 724–D, slide 7, coordinates 113.5 × 16.4, negative number 4937. Maximum diameter of the specimen is 44.7 microns.

Figure 6. Fungal(?) cells, USGS Paleobotanical loc. No. D6643–B, roof rock of the Little Raleigh coal bed, maceration 728–A, slide 2, coordinated 109.0 × 6.3, negative number 4926. Maximum diameter of the specimen is 68.3 microns.

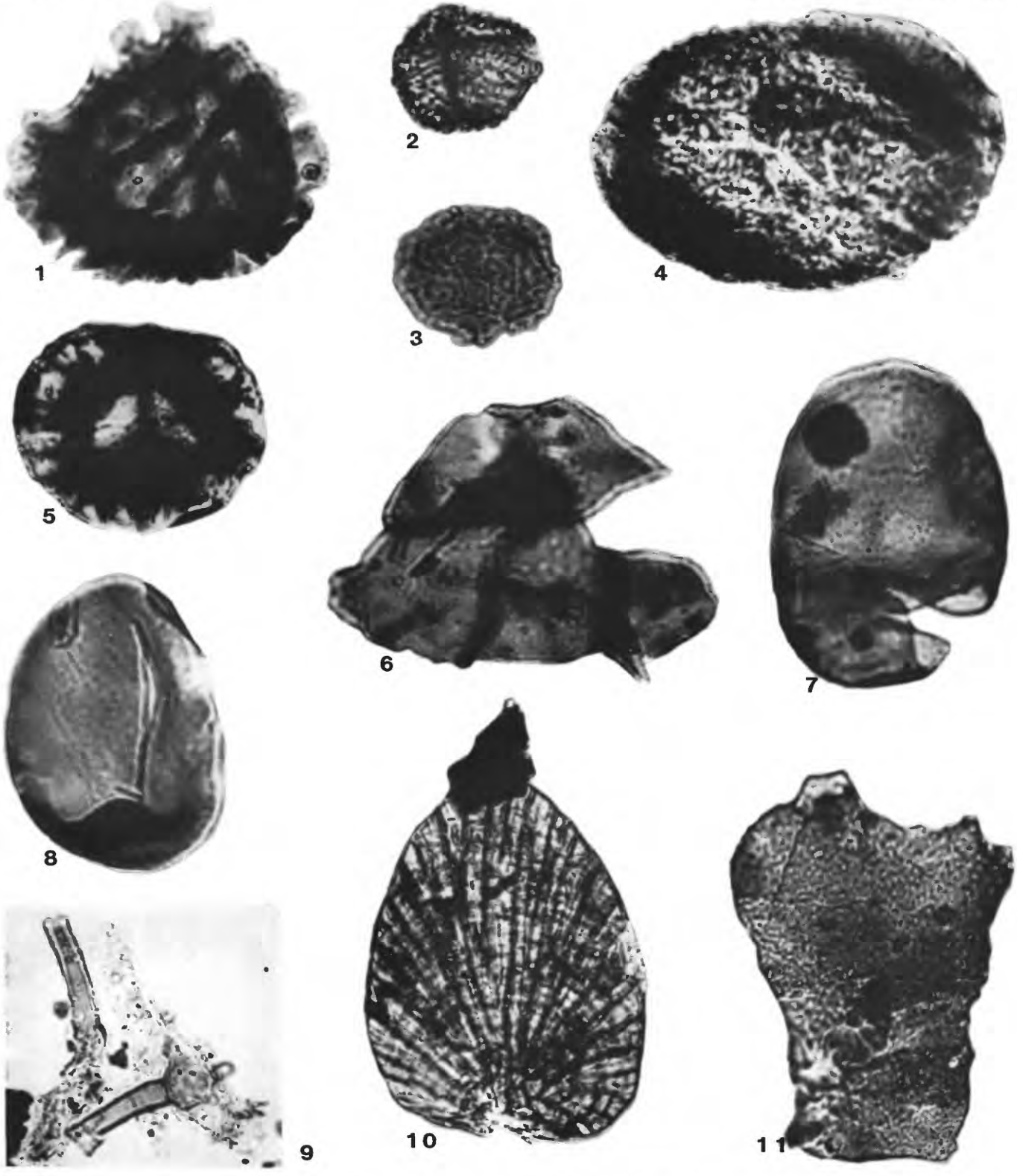
Figure 7. *Laevigatosporites* sp. 1, USGS Paleobotanical loc. No. D6639–B, unnamed coal bed in Nuttall Sandstone Member, maceration 723–B, slide 2, coordinates 107.6 × 6.9, negative number 4916. Maximum diameter of specimen is 60.4 microns.

Figure 8. *Laevigatosporites* sp. 1, USGS Paleobotanical loc. No. D6639–B, unnamef coal bed in the Nuttall Sandstone Member, maceration 723–B, slide 6, coordinates 113.0 × 7.3, negative number 4914. Maximum diameter of the specimen is 53.9 microns.

Figure 9. Fungal cells, USGS Paleobotanical loc. No. D6643–B, roof rock of the Little Raleigh coal bed, maceration 728–A, slide 2, coordinates 113.4 × 5.2, negative number 4902. Maximum diameter of cell is 36.8 microns.

Figure 10. Animal scale(?), USGS Paleobotanical loc. No. D6643–B, Little Raleigh coal bed, maceration 728–A, slide 1, coordinates 121.5 × 4.1, negative number 4901. Maximum width of scale 65.7 microns and estimated length 92.0 microns.

Figure 11. Animal pellicle(?), USGS Paleobotanical loc. No. D6639–B, unnamed coal bed in the Nuttall Sandstone Member, maceration 723–B, slide 2, coordinates 112.6 × 11.3, negative number 4915. Maximum length of the specimen is 94.6 microns.



CRISTATISPORITES, SCHULZOSPORA, RADIIZONATES, LAEVIGATOSPORITES, FUNGAL CELLS, ANIMAL SCALE(?), AND ANIMAL PELLICLE(?)