Palynological Analyses of Upper Pennsylvanian Coal Beds and Adjacent Strata From the Proposed Pennsylvanian System Stratotype in West Virginia

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Palynological Analyses of Upper Pennsylvanian Coal Beds and Adjacent Strata From the Proposed Pennsylvanian System Stratotype in West Virginia

By ROBERT M. KOSANKE

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CONVERSION FACTORS

For readers who wish to convert measurements from the metric system of units to the inch-pound system of units, the conversion factors are listed below.

Metric unit	Multiply by	To obtain inch-pound unit
centimeter (cm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile

PALYNOLOGICAL ANALYSES OF UPPER PENNSYLVANIAN COAL BEDS AND ADJACENT STRATA FROM THE PROPOSED PENNSYLVANIAN SYSTEM STRATOTYPE IN WEST VIRGINIA

By ROBERT M. KOSANKE

ABSTRACT

The Upper Pennsylvanian Series in the proposed Pennsylvanian System stratotype consists of the Conemaugh and Monongahela Formations and the basal part of the Dunkard Formation to the top of the Waynesburg Sandstone of Krebs (1911). The geographic area of these exposures is from north of Charleston, West Virginia, along Interstate 77 to Kenna and Statts Mills, a distance of about 40 kilometers.

The coal beds of the Upper Pennsylvanian Series of the stratotype are generally thin and local although the Pittsburg No. 8 and Redstone or Pomeroy coal beds in the lowest part of the Monongahela Formation are thicker. Samples from these beds were collected, prepared, and examined for palynomorphs. Although preservation of the palynomorphs is poor or palynomorphs are absent in many samples, it has been possible to establish the distribution and abundance of palynomorph taxa present in some 60 samples.

A major change in palynomorph occurrence has been noted near the base of the Conemaugh Formation with the extinction of *Lycospora* spp., *Torispora securis*, and *Thymospora pseudothiessenii*. This change is followed by a sharp increase in abundance of *Endosporites*, mostly *E. globiformis*. Toward the Conemauagh-Monongahela boundary, *E. globiformis* and *Laevigatosporites* spp. decrease in abundance. At the epibole of *Thymospora thiessenii* (the Pittsburgh No. 8 coal bed), these two taxa represent less than 10 percent of the assemblage. The abundance of *T. thiessenii* is sharply reduced above the Pittsburgh No. 8 coal bed and is replaced by an abundance of *Laevigatosporites minutus* and *L. globosus*. The remainder of the Monongahela Formation into the lower part of the Dunkard Formation contains various species of *Laevigatosporites* as the dominant palynomorph. A new species of *Thymospora* represents more than one fourth of the assemblage of the Waynesburg "A" coal bed of Krebs (1911) in the Dunkard Formation.

Three new taxa are described because they occur in sufficient numbers to warrant description and they have some stratigraphic value. These are *Thymospora parva* sp. nov., *Laevigatosporites clendeningii* sp. nov., and *L. subovalis* sp. nov. *L. subovalis* is recognized throughout the Conemaugh and Monongahela Formations, whereas the other two taxa originate in the upper part of the Conemaugh Formation and are present in the Monongahela and Dunkard Formations.

INTRODUCTION

Throughout much of the northern Appalachians, the Upper Freeport coal bed is recognized as the uppermost stratigraphic unit of the Allegheny Formation (Charleston Sandstone). The Upper Freeport coal bed is not present in the proposed stratotype area. "The Middle-Upper Pennsylvanian Series boundary is at the base of a dark-greenish shale at the gradational contact between the Charleston Sandstone and the Conemaugh Formation," according to Englund and others (1986). The Conemaugh Formation, according to Henry, Lyons, and Windolph (1979), is greenish gray and about 500 ft (153 m) thick. About 60 percent of the Conemaugh is grayish-red mudrock, 30 percent is sandstone, and 10 percent is gray carbonaceous shale, limestone, flint clay, and coal. Coal beds, which are common in the Middle Pennsylvania Series of the Stratotype, are thin or lacking in the Conemaugh Formation. Windolph (1987), in the columnar section for the Big Chimney 7½-minute quadrangle, depicts several thin coal beds and questionably assigns two of these to the Brush Creek and Little Clarksburg coal beds. Named coal beds are recognized in other parts of West Virginia, western Pennsylvania, and Ohio. Arkle and others (1979) listed five named coal beds in West Virginia. Edmunds and others (1979) listed 13 named coal beds in the Conemaugh Formation of the Main Bituminous and Georges Creek coal fields of western Pennsylvania. Collins (1979) listed 13 named coal beds in the Conemaugh Formation of Ohio. Although these coal beds are well defined and named, they are not major commercial coal beds such as the Upper Freeport or the Pittsburgh No. 8; some of these coal beds may be mined locally, however. The coal beds of the stratotype are thin and impure, and for the most part, palynomorphs are poorly preserved. Also, much of the dispersed organic matter is degraded. A number of noncoal samples generally are not so adversely affected. However, the stratigraphic distribution of the productive samples of the stratotype allows a fairly good coverage of palynomorph occurrence through the Conemaugh Formation.

The boundary of the Conemaugh Formation with the overlying Monongahela Formation has been placed at

the base of the Pittsburgh No. 8 coal bed in West Virginia, western Pennsylvania, and Ohio. This boundary in the stratotype is placed at the base of a thick coal bed in the Divide section, Stop 24 of Henry, Gillespie, and others (1979), which palynologically is very similar to the Pittsburgh No. 8 coal bed (Kosanke 1943, 1984). This thick coal bed, named the Raymond City coal bed by Hotchkiss (1880), occurs north of Charleston, W. Va., along Interstate 77 for 8.9 km (5.5 mi) to Pocatalico. White (1885, 1903) correlated this coal with the Pittsburgh No. 8 coal bed as did Krebs and Teets (1914), Haught (1967), and Cross (1971). This bed is the basalmost stratigraphic unit in the Monongahela Formation. North of Pocatalico, the coal bed is replaced by a thin carbonaceous shale that rests just above a seat rock unit according to Henry, Lyons, and Windolph (1979). The coal bed is correlative with the Pittsburgh No. 8 coal bed, which is the most important commercial coal bed in the northern Appalachians. "Available maps show that the Raymond City is not an outlier of the Pittsburgh but fringes to the NE side of the Dunkard Basin to Penn." (K.J. Englund, written commun., 1987).

The Monongahela Formation in the stratotype area varies in thickness from 295 ft (89.9 m) to 390 ft (118.9 m) according to Henry, Lyons, and Windolph (1979) and is similar to the Conemaugh Formation below in that it contains about 50 percent mudrock or mudstone which is grayish red and greenish gray. There is also about 35 percent sandstone, 15 percent gray shale, carbonaceous shale, claystone, coal, and nonmarine limestone in the formation. With the exception of the Pittsburgh No. 8 coal bed and perhaps one other, the coal beds of the Monongahela of the stratotype are not economically important because they are thin, impure, and lenticular according to Henry, Lyons, and Windolph (1979). A coal bed occurring about 70 ft above the Pittsburgh No. 8 coal bed in the stratotype contains a palynomorph assemblage that is interesting in that it is similar to the assemblage of the Pomeroy coal bed of Ohio (Kosanke, 1943), which should be equivalent to the Redstone coal bed of West Virginia.

According to Henry, Lyons, and Windolph (1979), the "Waynesburg" Sandstone, which is the basal stratigraphic unit of the Dunkard Formation in the Interstate 77 corridor in the area of the stratotype, is different from the Waynesburg Sandstone of southwestern Pennsylvania. The geographic location of the Interstate 77 corridor is north of Charleston, W. Va., toward the Kanawha River as illustrated by Henry, Lyons, and Windolph (1979) in their figure 71. They report the "Waynesburg" Sandstone of the stratotype averages about 60 ft (18.3 m) in thickness but locally may exceed 80 ft (24.4 m).

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U.S. Geological Survey colleagues have been most generous in helping with collection and preparation of samples as well as discussions on the stratigraphy of the Upper Pennsylvanian Series of the stratotype. I am most grateful to T.W. Henry, K.J. Englund, H.H. Arndt, J.R. Scholten, and M.E. Zayhowski.

SAMPLE METHODS, PREPARATION, AND LOCALITIES

Sample methods and preparation have been discussed previously (Kosanke, 1950, 1973, 1977, 1984) and need not be repeated. More than 100 samples were collected, but only 73 samples yielded abundant, well-preserved palynomorphs. Fortunately, productive samples were distributed sufficiently throughout the Conemaugh and Monongahela Formations to provide an insight on palynomorph abundance and distribution. Also, palynomorph information is available for comparison with parts of the Conemaugh and Monongahela Formations of Ohio.

All samples were assigned laboratory maceration numbers, and all productive samples were assigned USGS Paleobotanical locality numbers (D numbers). The stratigraphic nomenclature employed follows that of Englund and others (1986), Henry, Gillespie, and others (1979), and Henry, Lyons, and Windolph (1979).

The following samples are reported in this paper (see figure 1 for location of sample sites):

Canneloid coal, shale, and siltstone, units 9, 10, and 33, Henry's section 3 (written commun., Dec. 1, 1976), Charleston East 7½-minute quadrangle, Kanawha County, 910 m south of north line and 2,835 m east of west line, D6838, macerations 502-A-C. Units 9 and 10 are of Middle Pennsylvanian age, whereas the sample from unit 33 is from the lower part of the Conemaugh Formation.

Miscellaneous samples from units 1-3 and 5-6, Henry's section 12 (written commun., Dec. 1, 1976), Pocatalico 7½-minute quadrangle, Kanawha County, 840 m west of east line and 1,130 m north of Two Mile Creek, D6839, macerations 504-A-E. These samples are from the lower part of the Conemaugh Formation.

Unnamed coal, Conemaugh Formation, units 26 and 28, Newhouse Branch section, from west cutbank of Interstate 77 and U.S. Highway 79, north of Charleston, Big Chimney 7½-minute quadrangle, Kanawha County. D6793, macerations 460-A-B.

Unnamed, impure coal and miscellaneous samples, Conemaugh Formation from units 5-9 and 12-13

of Sheldon Rock Branch section from south-facing spur of Interstate 77, 482 m north of a point where Interstate 77 crosses Sheldon Rock Branch and 1,448 m southeast of the Eden Fork interchange, Big Chimney 7½-minute quadrangle, Kanawha County. D6795, macerations 462-A-G.

Unnamed coal and seat rock samples, Conemaugh Formation, units 2-12, Wallace Heights School section, stop 25 of Henry, Gillespie, and others (1979), 2.6 km south of Pocatalico, Pocatalico 7½-minute quadrangle, Kanawha County. D6798, macerations 565-A-L.

Unnamed coal, upper Conemaugh Formation, from an exposure along Pocatalico Creek, 1,448 m north of the Kanawha-Jackson County line, Jackson County, Sissonville 7½-minute quadrangle. D6795, macerations 465-A-B.

Pittsburgh No. 8 coal bed, Monongahela Formation, Divide section of Henry and others (1979), 1.6 km south of Tupper Creek Road along Interstate 77, Pocatalico 7½-minute quadrangle, Kanawha County. See table 19 of Kosanke (1984) for a summary analysis of these samples. D6043, macerations 428-A-C.

Pomeroy or Redstone coal bed, Monongahela Formation, units 2, 4, and 8 of Wolfpen Hollow section, 0.9 km west-northwest of stop 24, the Divide section of Henry, Gillespie, and others (1979) as shown on their figure 42, Pocatalico 7½-minute quadrangle, Kanawha County. D6796, macerations 472-A-I.

Unnamed coal bed, middle Monongahela Formation, from units 9-10, Loop section, stop 27 of Henry, Gillespie, and others (1979), just north of the Jackson-Kanawha County line in southern Jackson County along Interstate 77, Sissonville 7½-minute quadrangle. D6797, macerations 538-A-C.

Waynesburg coal sequence, Devils Den Hollow section, Kenna 7½-minute quadrangle, Jackson County. Unit 15 is a carbonaceous seat rock; D6938, macerations 510-A-C. Unit 16 is the Waynesburg coal bed of Krebs (1911); D6938, macerations 511-A-E.

Waynesburg "A" coal bed of Krebs (1911), lower Dunkard Formation from outcrop in lefthand tributary of Painters Branch, located 63.9 m north-northwest of bench mark 776 at Liberty, Sissonville 7½-minute quadrangle, Putnam County. D6842, macerations 644-A-F.

Holmes Knob diamond drill core, samples from Conemaugh Formation, productive samples from 17.0-17.6 m and 129.6-130.3 m and below the Pittsburgh No. 8 coal bed. The core hole is located at the head of Holmes Branch 0.7 km southwest of bench mark 1027 and 0.65 km southeast of Holmes Knob, Big Chimney 7½-minute quadrangle, Kanawha County. D6842, macerations 852-A-M.

PALYNOMORPHS FROM CONEMAUGH FORMATION

The Mahoning coal bed, the oldest coal bed in the Conemaugh Formation, is not recognized in the stratotype area. In parts of West Virginia, western Pennsylvania, and eastern Ohio, this coal bed is transitional palynologically from the Allegheny Formation below. This is because *Lycospora* spp., *Thymospora pseudothiessenii*, and even *Torispora securis* are greatly reduced in abundance in the Mahoning coal bed and are absent in the Brush Creek coal bed above. Kosanke (1947, 1950) reported that *Lycospora* spp. and *Thymospora pseudothiessenii* became extinct between two unnamed coal beds (2d and 3d Cutler rider coal beds) of the McLeansboro Group in Illinois. *Torispora securis*, was not split off the genus *Laevigatosporites* (Balme 1962) until later. Kosanke (1973) found these taxa present in the Princess No. 9(?) coal bed of northeastern Kentucky, but absent from the Brush Creek coal bed above. The sample of the Brush Creek coal was badly weathered so it was uncertain whether these taxa were validly missing or absent because of lack of preservation. Peppers reported in Phillips and others (1985) that *Lycospora* was not present in the Brush Creek coal bed in the northern Appalachian region.

Thompson (1936) described the fulsulid *Triticites ohioensis* from the Brush Creek and Cambridge Limestones of the Conemaugh Formation of Ohio. Dunbar and Henbest (1942) reported, "The genus *Triticites* appears in America *** at the boundary between the Des Moines and Missouri groups emphasize the faunal break between these two groups. This is one of the most important faunal breaks in the Pennsylvanian System." Palynological evidence from Ohio suggests that terrestrial plants underwent a major change just prior to the start of the *Triticites* range zone in the lower part of the Conemaugh Formation. In Illinois, the extinction of *Lycospora* spp., *Thymospora pseudothiessenii*, and *Torispora securis* occurs within the Desmoinesian Series just below the Desmoinesian-Missourian Boundary. Thus, there is sufficient evidence from both plants and animals that a major change occurs close to the Middle-Upper Pennsylvanian Series boundary in the Midcontinent and Eastern United States.

Three samples were collected from T.W. Henry's section 3, Charleston East 7½-minute quadrangle, West Virginia. These samples were from units 9, 10, and 33, and were assigned to D6838 and maceration series 502. Samples 502-A and 502-B, units 9 and 10, respectively,

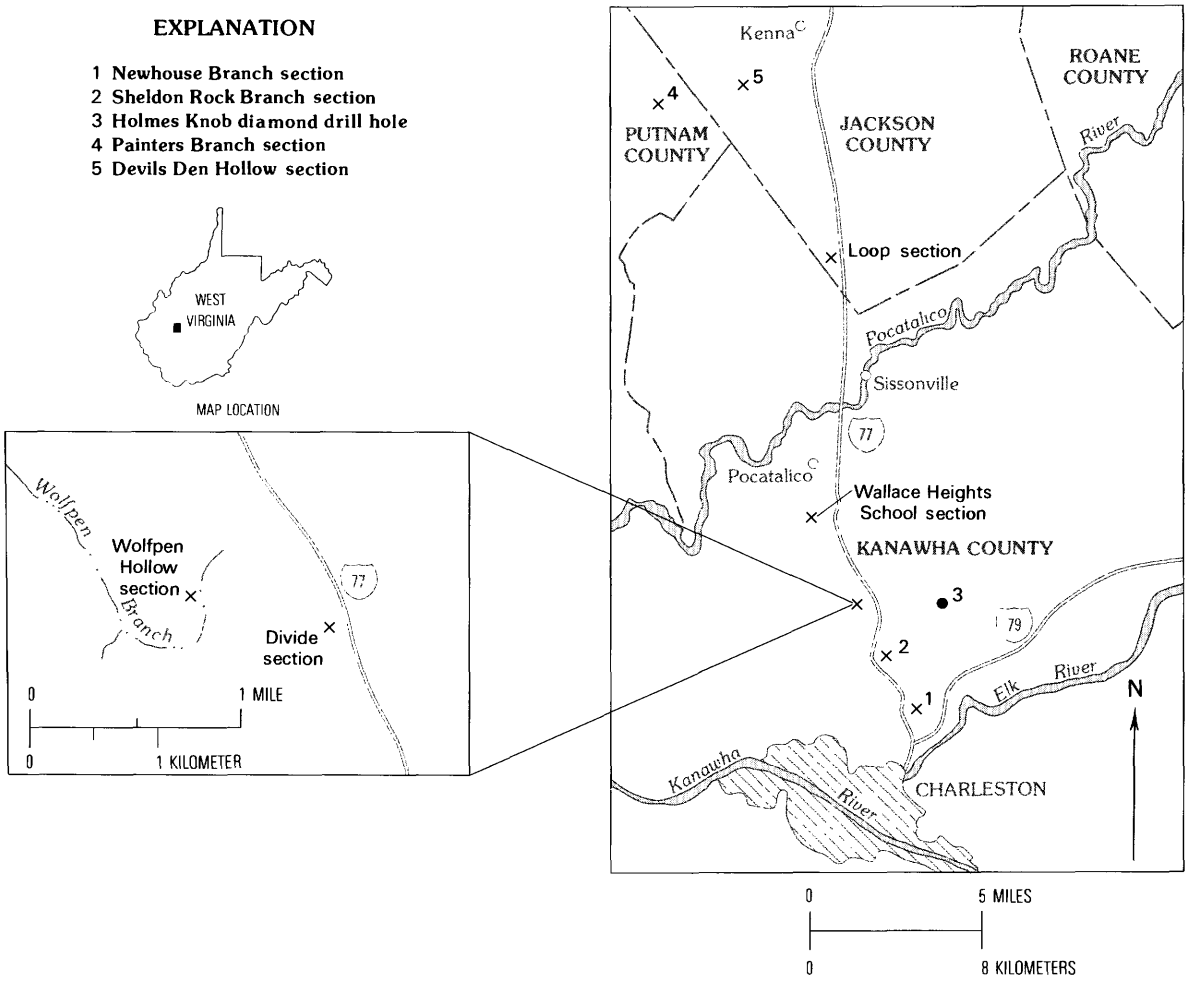

FIGURE 1.—Geographic location of six productive palynomorph collecting sites and one diamond drill hole. This figure is adapted from figure 42 of Henry, Gillespie, and others (1979) and figure 71 of Henry, Lyons, and Windolph (1979).

contained palynomorphs not known to occur in the Conemaugh Formation. These palynomorphs are *Radiizonates*, *Cristatisporites*, and *Densosporites*. The extinction of these taxa in the stratotype is in the No. 5 Block coal bed (Kosanke, 1984). In the Princess Reserve District of northeastern Kentucky, the last occurrence of *Densosporites* is in the Princess No. 7 coal bed, and a single specimen of *Cristatisporites* was observed in the Princess No. 6 coal bed. The absence of *Lycospora*, *Thymospora*, and *Torispora* in maceration 502-C (unit 33) indicates this sample is significantly younger than the samples represented by macerations 502-A and -B. This is further suggested by the presence of *Cadiospora* and *Gillespieisporites* in maceration 502-C. Also, the abundance of *Endosporites globiformis* is consistent with these data. The taxa identified from macerations 502-A–C are given in table 1.

Five samples of coal, carbonaceous shale, and seat rock were collected from Henry's Pocatalico section 12, Pocatalico 7½-minute quadrangle, and assigned to maceration series 504. All samples yielded palynomorphs, but only a coal and carbonaceous shale sample, maceration 504-D, yielded abundant palynomorphs. The taxa identified are shown in table 2. *Endosporites* accounts for 48 percent of the spore population, and *Punctatisporites minutus* accounts for 15 percent. The overall abundance of *Endosporites* decreases toward the Conemaugh-Monongahela boundary. An increase in *Endosporites*, primarily *E. globiformis*, has been observed in samples from a lower part of the Conemaugh Formation of Ohio. *Laevigatosporites*, which represents 37 percent of the palynomorph population of maceration 502-C, is present in maceration 504-D only to the extent of 5 percent. However, eight species of *Laevigatosporites* have been identified from samples of the 504 maceration series.

TABLE 1.—*Palynomorphs from lower Charleston Sandstone and lower Conemaugh Formation, section 3 (Henry)*

[Charleston East 7½-minute quadrangle, Kanawha County, W. Va. Macerations 502-A–B, samples from lower Charleston Sandstone; maceration 502-C, lower Conemaugh Formation; USGS Paleobotanical loc. No. D6838 A–C; X indicates taxon not observed or count not attempted]

Taxon	502-A	502-B (percent)	502-C
Apiculatisporites sp	—	—	X
Cadiospora sp	—	—	X
Calamospora breviradiata Kosanke	X	—	X
C. sp	—	0.5	1.0
Cirratriradites sp	X	—	—
Crassispora kosankei (Potonié and Kremp) Bharadwaj	—	2.5	.5
Cristatisporites indignabundus (Loose) Staplin and Jansonius	—	.5	—
Cyclogranisporites multigranus Smith and Butterworth	X	—	—
C. obliquus (Kosanke) Upshaw and Hedlund	—	—	2.0
C. sp	—	—	.5
Densosporites annulatus (Loose) Schopf, Wilson, and Bentall	X	—	—
D. sphaerotriangularis Kosanke	X	.5	—
D. sp	X	—	—
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	X	1.0	25.5
E. sp	—	—	2.0
Florinites similis Kosanke	—	—	2.0
F. sp	—	—	2.0
Gillespieisporites venustus Clendening	—	—	2.5
Granulatisporites granulatus Ibrahim	—	2.0	X
G. sp	—	.5	1.5
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	X	1.0	.5
L. globosus Schemel	X	3.5	7.5
L. latus Kosanke	—	.5	.5
L. medius Kosanke	X	1.0	.5
L. minimus (Wilson and Coe) Schopf, Wilson, and Bentall	—	X	X
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	X	24.5	23.0
L. ovalis Kosanke	X	5.5	3.0
L. punctatus Kosanke	—	.5	—
L. subovalis sp. nov	—	4.5	1.5
L. vulgaris Ibrahim	X	1.0	.5
Leiotriletes adnatus (Kosanke) Potonié and Kremp	—	—	4.5
L. sp	—	—	X
Lycospora granulata Kosanke	X	X	—
L. micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall	X	2.5	—
L. pellucida (Wicher) Schopf, Wilson, and Bentall	X	3.5	—
L. spp	X	11.5	—
Microreticulatisporites cf. *M. nobilis* (Wicher) Knox	—	—	X
M. sulcatus (Wilson and Kosanke) Smith and Butterworth	X	1.0	.5
Punctatisporites minutus (Kosanke) Peppers	—	—	6.5
P. sp	—	X	2.5
Radiizonates cf. *R. difformis* (Kosanke) Staplin and Jansonius	X	2.0	—
Torispora securis Balme	X	22.5	—
Triquitrites minutus Alpern	—	—	4.0
T. pulvinatus Kosanke	X	1.0	—
T. sculptilis (Balme) Smith and Butterworth	—	2.5	—
T. spp	X	3.0	3.5
Verrucosisporites sp	—	X	—
Vestispora cf. *V. fenestrata* (Kosanke) Spode in Smith and Butterworth	X	—	—
V. sp	X	—	—
Monosaccate	—	1.0	1.0
Bisaccate	—	—	1.0
Unassigned	—	X	—
Total		100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

502-A, 9.1 cm canneloid coal, unit 9[1].
502-B, 15.2 cm silty shale and siltstone, unit 10[1].
502-C, 3.0 cm silty shale, unit 33.

[1]Contains palynomorphs of Middle Pennsylvanian age.

GENERIC SUMMARY OF 502-B AND 502-C (in percent)

	502-B	502-C
Endosporites	X	27.5
Florinites	—	4.0
Laevigatosporites	42.0	37.0
Lycospora	17.5	—
Punctatisporites	X	11.0
Torispora	22.5	—
Triquitrites	6.5	7.5
Total	88.5	86.0

TABLE 2.—*Palynomorphs from lower Conemaugh Formation, section 12 (Henry), units 1-3 and 5-6*

[Pocatalico 7½-minute quadrangle, Kanawha County, W. Va. Unnamed coal and adjacent strata assigned to macerations 504-A-E, USGS Paleobotanical loc. No. D6839 A-E; X indicates palynomorphs present but not observed or count not attempted]

Taxon	504-A	504-B	504-C (percent)	504-D	504-E
Acanthotriletes echinatus (Knox) Potonié and Kremp	—	—	X	X	—
Apiculatisporis abditus (Loose) Potonié and Kremp	—	—	—	X	X
A. sp	—	—	—	—	X
Cadiospora magna Kosanke	—	X	—	X	—
Calamospora breviradiata Kosanke	—	—	—	2.0	—
C. hartungiana Schopf in Schopf, Wilson, and Bentall	—	—	—	5.0	—
C. sp	—	—	X	—	—
Cirratriradites annulatus Kosanke and Brokaw	—	—	—	1.0	—
Crassispora kosankei (Potonié and Kremp) Bharadwaj	—	—	—	1.0	—
Cyclogranisporites aureus (Loose) Potonié and Kremp	—	—	—	—	X
C. cf. *C. multigranus* Smith and Butterworth	—	—	—	X	—
C. spp	—	—	—	6.0	—
Endosporites cf. *E. formosus* Kosanke	—	—	—	8.0	—
E. globiformis (Ibrahim) Schopf, Wilson, and Bentall	X	—	—	40.0	—
E. sp	—	X	—	—	—
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	—	—	—	3.0	X
F. sp	—	—	—	X	X
Gillespieisporites venustus Clendening	—	—	—	6.0	X
Granulatisporites granulatus Ibrahim	X	—	—	1.0	—
G. minutus Potonié and Kremp	—	—	—	1.0	X
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	—	1.0	—
L. globosus Schemel	X	—	—	—	—
L. latus Kosanke	X	—	—	—	—
L. medius Kosanke	X	—	—	—	—
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	X	X	X	3.0	X
L. ovalis Kosanke	X	X	X	1.0	X
L. subovalis sp. nov	X	—	—	—	—
L. vulgaris Ibrahim	—	—	X	—	—
L. sp	X	—	—	—	—
Leiotriletes sp	X	—	—	—	—
Lophotriletes sp	X	—	—	—	X
Microreticulatisporites sp	—	—	—	—	X
M. sulcatus (Wilson and Kosanke) Smith and Butterworth	—	—	—	—	X
M. sp	—	—	—	1.0	—
Pityosporites westphalensis Williams	X	—	—	—	—
Punctatisporites minutus (Kosanke) Peppers	X	X	—	15.0	X
P. spp	X	X	X	X	X
Triquitrites sculptilis (Balme) Smith and Butterworth	—	—	X	—	X
T. spinosus Kosanke	—	—	—	—	X
T. spp	—	—	—	1.0	—
Trivolites laevigata Peppers	—	—	—	—	X
Verrucosisporites sp	—	—	—	1.0	—
Wilsonites Vesicatus (Kosanke) Kosanke	X	X	X	—	—
Monosaccate	X	X	X	1.0	X
Unassigned	X	—	—	2.0	X
Total				100.0	

DESCRIPTION OF MATERIAL IN MACERATIONS

504-A, 9.1 cm seat rock, carbonaceous, unit 1.
504-B, 12.1 cm seat rock with partings, unit 2.
504-C, 6.0 cm silty carbonaceous shale, unit 3.
504-D, 9.1 cm coal and carbonaceous shale, unit 5.
504-E, 15.2 cm gray shale, unit 6.

GENERIC SUMMARY OF 504-D (in percent)

Calamospora	7.0
Cyclogranisporites	6.0
Endosporites	48.0
Gillespieisporites	6.0
Punctatisporites	15.0
Total	82.0

A specimen of *Trivolites laevigata* Peppers was identified from maceration sample 504-E from a gray shale (unit 6). This taxon was described by Peppers (1964) from the Trivoli cyclotherm of Illinois. He also identified this taxon from the Hernshaw Formation of western Kentucky (Peppers, 1964) and from the Lowell coal of Illinois (Peppers, 1970). *Trivolites* is not found in abundance but is readily identifiable. Macerations 504-B and 504-D contain *Cadiospora magna*.

Two samples of weathered, pyritic coal, units 26 and 28, were collected from the Newhouse Branch section (fig. 1). These samples were assigned to maceration series 460 and were collected from north of Charleston, W. Va. Preservation and recovery of palynomorphs was poor. The taxa identified from the macerations are listed in table 3. The assemblage of palynomorphs listed is very small, and these taxa occur both above and below the stratigraphic horizon.

Seven sets of samples were collected from the Sheldon Rock Branch section, which is located along Interstate 77, 1,448 m southeast of the Eden Fork interchange (fig. 1), and assigned to maceration series 462. All seven sets of samples yielded palynomorphs, and abundance counts were feasible with four of the seven sets. The taxa identified are shown in table 4. These samples are a mixture of impure coal, canneloid shale, and subcarbonaceous seat rock. The assemblage of palynomorphs is not extensive although 16 genera have been identified. *Laevigatosporites* is dominant in 462-A and -B, and *Endosporites* dominates the assemblage of palynomorphs in 462-D and -E. A generic summary of sample 462-A, a carbonaceous shale and impure coal sample, shows *Laevigatosporites* dominant with nearly one-half the assemblage identified as this genus. Two species of *Laevigatosporites* are important in this sample with *L. globosus* and *L. minutus* constituting 46 percent of the spore population. *Endosporites*, and *Florinites* are next in numerical importance in sample 462-A. Noncoal samples 462-B, 462-D, and 462-E of this maceration series contained sufficient palynomorphs to permit a good abundance count. Sample 462-B is similar to 462-A; however, in macerations 462-D and 462-E, *Endosporites globiformis* is the most abundant taxon.

Twelve sets of samples were collected from the Wallace Heights School section, stop 25 of Henry, Gillespie, and others (1979), from a roadcut in the Interstate 77 corridor, Kanawha County, W. Va. (fig. 1). These samples were assigned to macerations 565-A-L. Although many taxa were identified from these samples, abundance counts were not undertaken due to the low abundance of palynomorphs. Nevertheless, some very important taxa occur in these samples. For example, the presence of *Thymospora thiessenii* in several of the lower samples of this series represents the start of its range zone at more than 52 m below the Pittsburgh No. 8 coal bed. The Pittsburgh No. 8 coal bed is the epibole (acme-zone) of *T. thiessenii*. Three other taxa that apparently originate in the 565 maceration series along with *T. thiessenii* are *Fabasporites*, *Laevigatosporites clendeningii* sp. nov., and *Thymospora parva* sp. nov. These three taxa were recognized by Clendening (1974) in his study of the palynomorphs of the Dunkard Group.

Sullivan (1964) described two new genera and a number of new species from the Drybrook Sandstone in the Forest of Dean Basin, Gloucestershire, Great Britain. One new genus was *Fabasporites*, and the type species was *F. pallidus*. This taxon, which is small, varies in diameter from 13 to 23 microns. According to Sullivan, this taxon varies from levigate to finely granulate and does not possess a monolete aperture but characteristically has a fold which resembles an aperture. Clendening (1968) described three additional species of *Fabasporites*. One must question whether or not these taxa can be differentiated consistently inasmuch as they are very small and do not possess haptotypic structures that could aid in differentiation. Although they are unquestionably sporelike entities, it seems appropriate to list them as *Fabasporites* spp. as Clendening (1974) did. *Laevigatosporites clendeningii* sp. nov. and *Thymospora parva* sp. nov. are valid taxa and are described in this paper. A complete list of taxa identified from the samples of the Wallace Heights School section is given in table 5.

TABLE 3.—*Palynomorphs from a weathered coal, lower Conemaugh Formation, units 26 and 28 of the Newhouse Branch section*

[Located on a west cutbank of Interstate 77 on waters of Newhouse Branch at a point 0.6 km northwest of the intersection of Interstates 77 and 79 north of Charleston, Kanawha County, W. Va., Big Chimney 7½-minute quadrangle. Macerations 460-A-B, USGS Paleobotanical loc. No. D6793; X indicates presence of taxon]

Taxon	460-A	460-B
Calamospora sp	X	—
Convolutispora sp	—	X
Cyclogranisporites minutus Bharadwaj	X	—
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	X	X
Florinites cf. *F. visendus* (Ibrahim) Schopf, Wilson, and Bentall	X	X
Gillespieisporites venustus Clendening	X	—
Granulatisporites granulatus Ibrahim	X	—
Laevigatosporites globosus Schemel	X	—
L. minutus (Ibrahim) Schopf, Wilson and Bentall	X	—
Leiotriletes sp	—	X
Punctatisporites spp	X	X
Triquitrites sp	X	—
Wilsonites vesicatus (Kosanke) Kosanke	X	—

DESCRIPTION OF MATERIAL IN MACERATIONS

460-A, 18.2 cm coal, weathered, pyritic.

460-B, 12.1 cm coal, weathered, pyritic.

TABLE 4.—*Palynomorphs from thin, impure coal and carbonaceous shale, middle Conemaugh Formation, units 5-9 and 12-13 from Sheldon Rock Branch section*

[South-facing spur of Interstate 77, 482 m north of a point where Interstate 77 crosses Sheldon Rock Branch and 1,448 m southeast of the Eden Fork interchange, Big Chimney 7½-minute quadrangle. Macerations 462-A-G, USGS Paleobotanical loc. No. D6795 A-G; X indicates taxon present but not observed in count or count not attempted]

Taxon	462-A	462-B	462-C	462-D (percent)	462-E	462-F	462-G
Angulisporites cf. *A. splendidus* Bharadwaj	—	—	—	—	—	X	—
Cadiospora magna Kosanke	2.0	—	—	—	2.0	—	—
Calamospora breviradiata Kosanke	—	—	—	—	1.0	—	—
C. cf. *C. hartungiana* Schopf in Schopf, Wilson, and Bentall	—	—	—	—	—	X	—
C. sp	1.0	—	—	—	—	X	—
Crassispora kosankei (Potonié and Kremp) Bharadwaj	—	—	—	2.0	1.0	X	—
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	19.0	1.0	X	57.0	71.0	X	—
E. spp	X	X	X	1.0	6.0	X	—
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	5.0	—	—	—	—	X	—
F. similis Kosanke	—	—	—	14.0	4.0	—	—
F. sp	5.0	2.0	X	—	2.0	X	X
Granulatisporites granulatus Ibrahim	2.0	—	—	—	—	—	—
G. sp	2.0	4.0	—	1.0	1.0	—	—
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	—	1.0	—	—	—
L. globosus Schemel	35.0	47.0	X	2.0	2.0	X	X
L. latus Kosanke	1.0	—	—	—	—	X	—
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	11.0	26.0	—	2.0	1.0	X	X
L. subovalis sp. nov	—	1.0	—	1.0	2.0	X	—
Leiotriletes adnatus (Kosanke) Potonié and Kremp	1.0	—	—	1.0	—	—	—
L. sp	—	—	—	—	—	X	—
Lophotriletes sp	—	1.0	—	—	—	—	—
Microreticulatisporites sp	—	—	—	1.0	—	—	—
Punctatisporites minutus (Kosanke) Peppers	7.0	1.0	—	1.0	1.0	—	—
P. spp	—	1.0	—	3.0	—	X	X
Triquitrites subspinosus Peppers	X	6.0	X	1.0	—	—	—
T. sp	4.0	2.0	—	1.0	1.0	—	—
Vesicaspora sp	—	1.0	—	—	—	X	—
Vestispora fenestrata (Kosanke) Spode in Smith and Butterworth	—	—	—	2.0	—	—	—
Wilsonites vesicatus (Kosanke) Kosanke	2.0	1.0	—	2.0	—	X	—
Fungal cells	—	—	X	—	—	—	—
Monosaccate	3.0	4.0	X	5.0	4.0	X	X
Bisaccate	—	1.0	—	—	—	—	—
Unassigned	—	1.0	—	2.0	1.0	—	—
Total	100.0	100.0		100.0	100.0		

DESCRIPTION OF MATERIAL IN MACERATIONS

462-A, 15.2 cm carbonaceous shale and impure coal, unit 5.
462-B, 7.2 cm subcarbonaceous clayey seat rock, unit 6.
462-C, 1.5 cm canneloid shale, unit 7.
462-D, 9.1 cm carbonaceous clay shale, unit 8.
462-E, 122.4 cm canneloid carbonaceous shale, unit 9.
462-F, 0.6 cm impure coal, unit 12.
462-G, 6.0 cm subcarbonaceous shale, unit 13.

GENERIC SUMMARY OF 462-A (in percent)

Endosporites	19.0
Florinites	10.0
Laevigatosporites	47.0
Total	76.0

A coal bed along Pocatalico Creek 1,448 m north of the Kanawha-Jackson County line in Jackson County yielded an interesting although rather limited assemblage of palynomorphs. These samples, which are from the upper part of the Conemaugh Formation, were assigned to D6795 and macerations 465-A-B. *Laevigatosporites* is the numerical dominant, and *Cyclogranisporites* and *Crassispora* are present in the amount of 11 and 8 percent, respectively. Because these samples stratigraphically occur in the upper part of the Conemaugh Formation, one might expect *T. thiessenii*, which is present, to be more abundant as this taxon is very abundant just above in the Pittsburgh No. 8 coal bed. The taxa identified from maceration series 465 are shown in table 6.

Several sets of samples from the Holmes Knob core hole were available for palynomorph studies, but only two of these sets were productive. These two sets of samples were from the top and bottom of the Conemaugh Formation. The top set of samples came from the interval 17.0-17.6 m, and these samples were assigned to macerations 852-A-D. The bottom set of

TABLE 5.—*Palynomorphs from three thin coal layers and adjacent strata, upper Conemaugh Formation, units 2-8 from the Wallace Heights School section*

[West side of Interstate 77 about 2.1 km south of Pocatalico, Pocatalico 7½-minute quadrangle, Kanawha County, W. Va. Macerations 565-A-G, USGS Paleobotanical loc. No. D6798; X indicates presence of taxon]

Taxon	565-A	565-B	565-C	565-D	565-E	565-F	565-G	565-H	565-I	565-J	565-K	565-L
Acanthotriletes cf. *A. falcatus* (Knox) Potonié and Kremp	—	—	—	—	—	—	—	—	—	X	—	X
Apiculatisporis spp	—	—	—	—	—	—	—	—	—	—	—	X
Cadiospora magna Kosanke	—	—	—	—	—	—	—	—	—	X	X	—
Calamospora breviradiata Kosanke	—	—	—	X	X	—	—	—	—	—	—	X
C. sp	—	X	X	—	—	—	—	X	—	—	—	X
Crassispora kosankei (Potonié and Kremp) Bharadwaj	X	—	—	—	—	—	—	—	—	—	—	—
Cyclogranisporites cf. *C. minutus* Bharadwaj	—	X	—	—	—	—	—	—	—	—	X	—
C. spp	X	—	—	X	—	—	—	X	—	X	—	X
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	—	X	—	X	—	—	X	—	—	—	—	X
Fabasporites spp	X	X	—	—	X	—	X	—	—	X	—	—
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	X	—	—	—	—	X	X	—	—	—	—	X
F. sp	X	—	—	X	X	—	—	—	—	—	—	X
Gillespieisporites venustus Clendening	—	—	—	X	X	X	—	X	—	—	—	X
Granulatisporites minutus Potonié and Kremp	X	—	—	—	—	—	—	—	—	—	X	X
G. sp	X	—	—	—	—	—	—	—	—	X	X	X
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	X	X	—	—	X	X	—	—	X	X
L. medius Kosanke	—	—	—	—	—	—	X	—	—	—	—	—
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	X	X	X	X	X	X	X	X	—	X	X	X
L. ovalis Kosanke	X	X	X	X	X	X	X	X	X	X	X	X
L. subovalis sp. nov	X	—	—	—	X	—	—	X	—	X	X	X
L. vulgaris Ibrahim	—	—	—	X	—	—	—	X	—	—	—	—
L. sp. A (of Clendening)	—	—	—	X	—	—	—	X	—	—	—	X
Leiotriletes spp	X	X	—	—	—	—	X	X	—	—	—	—
Lophotriletes sp	—	X	—	—	—	—	—	—	—	—	—	—
Microreticulatisporites novicus Bharadwaj	X	—	X	X	—	—	—	X	—	—	X	—
Pityosporites sp	—	X	—	—	—	—	—	—	—	—	—	—
Punctatisporites obliquus Kosanke	X	X	—	X	X	X	—	—	—	—	—	—
P. spp	—	X	X	—	X	X	—	X	—	X	—	—
Raistrickia sp	—	—	—	—	—	—	X	—	—	—	X	—
Thymospora thiessenii (Kosanke) Wilson and Venkatachala	—	—	—	—	—	—	X	X	—	X	X	X
T. sp. A (of Clendening)	X	—	X	X	—	—	—	—	X	—	—	—
Triquitrites minutus Alpern	—	—	—	—	X	—	—	—	—	—	—	—
T. sp	—	—	X	—	—	—	X	—	—	—	—	X
Vesicaspora wilsonii (Schemel) Wilson	—	—	—	—	—	—	—	—	X	—	—	—
Wilsonites vesicatus (Kosanke) Kosanke	—	X	—	X	—	—	X	X	—	—	—	—
W. sp	—	—	—	X	—	—	—	—	X	X	X	—
Verrucosisporites donarii Potonié and Kremp	—	—	—	—	X	X	—	—	—	—	—	—
V. microtuberous (Loose) Potonié and Kremp	—	—	—	—	X	X	—	—	—	—	—	—
V. sifati (Ibrahim) Smith and Butterworth	—	X	—	—	—	—	—	—	—	—	—	—
V. spp	X	X	—	—	—	—	X	—	—	—	X	—
Monosaccate	X	—	X	X	—	—	X	X	—	X	—	X
Septate hyphae	—	—	—	—	X	—	—	—	—	—	—	—
Unassigned	—	—	X	—	—	—	—	X	—	—	—	—

DESCRIPTION OF MATERIAL IN MACERATIONS

565-A, 7.6 cm seat rock, unit 2.
565-B, 1.5 cm coal with carbonaceous shale laminae, unit 3.
565-C, 3.0 cm seat rock, unit 4.
565-D, 7.6 cm coal, unit 5.
565-E, 6.0 cm seat rock, unit 6.
565-F, 1.5 cm coal with carbonaceous shale laminae, unit 7.
565-G, 13.7 cm seat rock, unit 8.
565-H, 6.0 cm coal with carbonaceous shale laminae, unit 9.
565-I, 3.0 cm seat rock, unit 10.
565-J, 12.1 cm coal, impure, dull, unit 11.
565-K, 15.2 cm seat rock, unit 12.
565-L, 24.3 cm coal, impure, dull, much fusain, unit 13.

samples came from the interval 129.6-130.3 m, and these samples were assigned to macerations 852-I-M. Samples 852-A-D were taken a short distance below the Pittsburgh No. 8 coal bed which might represent the approximate position of the Little Pittsburgh coal bed in the northern Appalachian Basin. These samples are important because a fairly good palynomorph recovery was obtained, as shown on table 7. Species of

TABLE 6.—*Palynomorphs from upper Conemaugh Formation, exposure along Pocatalico Creek*

[1,448 m north of the Kanawha-Jackson County line, Sissonville 7½-minute quadrangle, Jackson County, W. Va. Macerations 465-A-B, USGS Paleobotanical loc. No. D6795 A-B; 200 specimens counted; X indicates presence of taxon and count not attempted]

Taxon	465-A	465-B
Calamospora sp	1.0	—
Crassispora kosankei (Potonié and Kremp) Bharadwaj	8.0	—
Cyclogranisporites cf. *C. minutus* Bharadwaj	1.0	X
C. sp	10.0	X
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	—	X
F. sp	1.0	X
Granulatisporites sp	—	X
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	11.0	—
L. globosus Schemel	19.0	X
L. medius Kosanke	5.0	—
L. minutus (Ibrahim) Schopf, Wilson and Bentall	16.0	X
L. punctatus Kosanke	1.0	—
L. ovalis Kosanke	12.0	X
L. subovalis sp. nov	4.0	—
L. sp	1.0	—
Punctatisporites minutus (Kosanke) Peppers	1.0	X
P. spp	3.0	X
Thymospora thiessenii (Kosanke) Wilson and Venkatachala	1.0	—
Verrucosisporites sp	1.0	X
Wilsonites sp	—	X
Monosaccate	3.0	X
Unassigned	1.0	—
Total	100.0	

DESCRIPTION OF MATERIAL IN MACERATIONS	GENERIC SUMMARY OF 465-A (in percent)	
465-A, 35.5 cm coal.	*Crassispora*	8.0
465-B, 11.4 cm coal.	*Cyclogranisporites*	11.0
	Laevigatosporites	69.0
	Total	88.0

Laevigatosporites dominate the palynomorph assemblage, but 24 other genera are present in these samples. In addition to *Laevigatosporites*, four other genera are numerically important: *Thymospora*, *Endosporites*, *Cyclogranisporites*, and *Punctatisporites*. It is significant that *Thymospora thiessenii* represents only 9 percent of the total assemblage in macerations 852-A-D but some 80 percent of the assemblage just above this horizon in the Pittsburgh No. 8 coal bed.

An interesting taxon that was identified from maceration 852-D is *Columinisporites ovalis*, originally described by Peppers (1964) from a shale (maceration 1170-G) in the Fithian cyclothem (Upper Pennsylvanian Series) of Illinois. Peppers (1964) described two additional species of this genus but recorded them only as species 1 and 2. These were from a shale unit within the Trivoli cyclothem, which stratigraphically would be close to the Desmoinesian-Missourian boundary. Peppers (1970) also reported *C. ovalis* in the Murphysboro coal bed from Grundy County in northern Illinois. The Murphysboro Coal Member is considered to be in the lower part of the Desmoinesian in Illinois. This taxon is not known to be present between the Murphysboro Coal Member and the Trivoli cyclothem. All the taxa identified in maceration 852-A-D are given in table 7.

Macerations 852-I-M are from the lower part of the Conemaugh Formation. Twenty-four genera have been identified even though 852-I and -K did not have sufficient palynomorphs to warrant abundance counts; the latter had good diversity, but palynomorphs were not abundant. Sample 852-I is a roof shale, and 852-K is the middle of the coal. All the coal samples were impure.

Macerations 852-I-M and 502-C are similar palynologically because both lack *Lycospora* and have a relative abundance of *Endosporites* in addition to overall similarity of other taxa, even though macerations 852-I-M are largely coal and 502-C is a silty shale as shown in table 8. Also, both of these sets of samples contain *Cadiospora* and *Gillespieisporites* which suggests a close relationship.

PALYNOMORPHS FROM MONONGAHELA FORMATION

A comparatively thick coal bed (106.5 cm, 42 in.) collected from a road exposure 1.6 km south of Tupper Creek Road along Interstate 77, Pocatahco 7½-minute quadrangle, Kanawha County, was identified as the Pittsburgh No. 8 coal bed (Kosanke, 1984) based on the overwhelming abundance of *Thymospora thiessenii*. This was discussed previously by Thiessen and Staud (1923), Kosanke (1943), and others and need not be discussed again. The Pittsburgh No. 8 coal bed marks the epibole of *Thymospora thiessenii*. Seventeen meters below, in macerations 852-A and -C, this taxon represents only 8 percent of the palynomorph assemblage, although in the noncoal samples 852-B and -D this percentage is somewhat higher. Seventeen meters above maceration 852-A, in the Pittsburgh No. 8 coal bed, presumably this taxon represents 80 or more percent of the palynomorph assemblage as shown in table 9.

FIGURE 2 (facing page).—Outline log of the available samples of the Holmes diamond drill core indicating the position of productive palynomorph samples which were at the top (852-A-D) and the bottom (852-I-M) of the core. These two sets of samples are from the top (852-A-D) and bottom (852-I-M) of the Conemaugh Formation as indicated by physical stratigraphy and the presence of selected palynomorph taxa in abundance such as *Thymospora thiessenii* (852-A-D) and *Endosporites globiformis* (852-I-M).

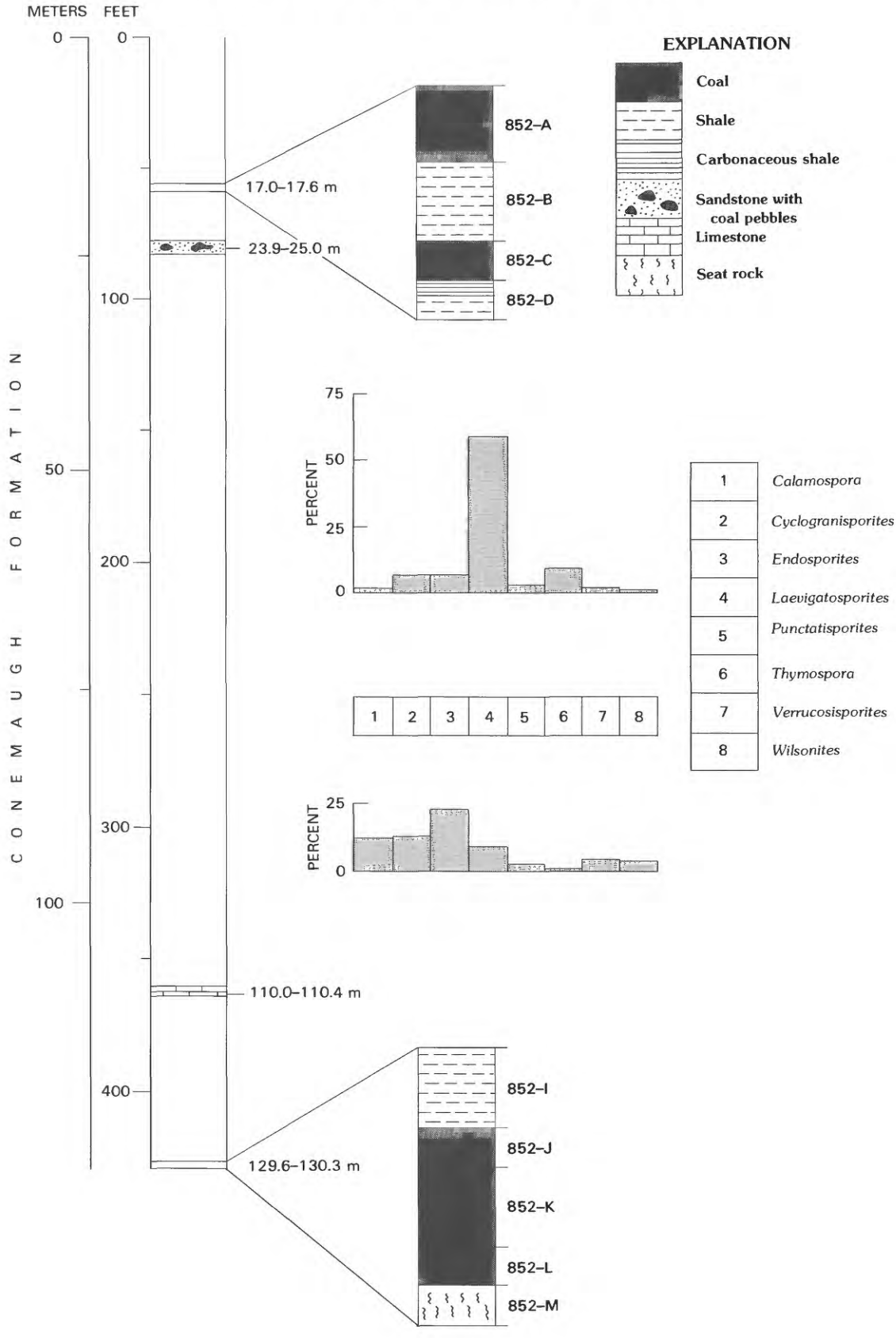
METERS
FEET
0
0
100
50
200
300
100
400
CONEMAUGH FORMATION
17.0–17.6 m
23.9–25.0 m
110.0–110.4 m
129.6–130.3 m
852–A
852–B
852–C
852–D
852–I
852–J
852–K
852–L
852–M
EXPLANATION
Coal
Shale
Carbonaceous shale
Sandstone with coal pebbles
Limestone
Seat rock
PERCENT
75
50
25
0
1 2 3 4 5 6 7 8
1 Calamospora
2 Cyclogranisporites
3 Endosporites
4 Laevigatosporites
5 Punctatisporites
6 Thymospora
7 Verrucosisporites
8 Wilsonites
PERCENT
25
0

TABLE 7.—*Holmes Knob diamond drill core, upper Conemaugh Formation*

[Productive samples from 17.0–17.6 m and 129.6–130.3 m. Hole location at head of Holmes Branch, 0.7 km southwest of bench mark 1,027 and 0.65 km southeast of Holmes Knob, Big Chimney 7½-minute quadrangle. Macerations 852-A–D, USGS Paleobotanical loc. No. D6842 A–D; X indicates taxon present but not encountered in count]

Taxon	852-A	852-B	852-C	852-D
		(percent)		
Ahrensisporites sp	—	—	2.0	X
Apiculatisporites cf. *A. spinosus* (Kosanke) Potonié and Kremp	—	—	—	2.0
A. sp. 1	—	33.0	1.0	—
A. sp	—	X	2.0	X
Cadiospora magnifica Kosanke	—	—	—	1.0
Calamospora breviradiata Kosanke	1.5	X	X	X
C. sp	3.0	—	2.0	—
Cirratriradites annulatus Kosanke and Brokaw	—	—	—	X
Columinisporites ovalis Peppers	—	—	—	2.0
Converrucosisporites sp	1.0	4.0	—	—
Convolutispora sp	—	1.0	X	3.0
Cyclogranisporites minutus Bharadwaj	1.5	2.0	—	—
C. multigranus Smith and Butterworth	4.0	3.0	3.0	1.0
C. sp	—	—	—	6.0
Dictyotriletes sp	—	—	—	X
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	—	—	21.0	6.0
E. zonalis (Loose) Knox	—	—	—	X
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	2.5	—	3.0	3.0
F. florini Imgrund	—	—	—	X
F. millotti Butterworth and Williams	—	1.0	—	—
F. sp	—	X	X	5.0
Gillespieisporites venustus Clendening	—	—	—	X
Granulatisporites sp	—	1.0	—	2.0
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	3.0	1.0	5.0	6.0
L. globosus Schemel	1.0	—	—	—
L. latus Kosanke	3.5	—	—	1.0
L. medius Kosanke	14.5	7.0	11.0	9.0
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	11.0	13.0	8.0	5.0
L. ovalis Kosanke	12.0	5.0	6.0	10.0
L. punctatus Kosanke	1.5	1.0	2.0	3.0
L. subovalis sp. nov	22.5	3.0	14.0	7.0
L. vulgaris Ibrahim	2.5	1.0	2.0	5.0
Leiotriletes cf. *L. sphaerotriangularis* (Loose) Potonié and Kremp	—	—	1.0	1.0
Microreticulatisporites sulcatus (Wilson and Kosanke) Smith and Butterworth	.5	—	—	—
M. sp	—	—	—	1.0
Pityosporites westphalensis Williams	—	—	—	X
Punctatisporites minutus (Kosanke) Peppers	2.0	—	—	3.0
P. spp	1.0	2.0	4.0	6.0
Reinschospora triangularis Kosanke	—	—	—	1.0
Thymospora thiessenii (Kosanke) Wilson and Venkatachala	7.5	20.0	9.0	10.0
T. sp	1.5	1.0	—	—
Trihypharcites triangularus Peppers	1.0	—	—	—
Verrucosisporites grandiverrucosus Kosanke	.5	—	—	—
V. cf. *V. microtuberosus* (Loose) Smith and Butterworth	.5	—	—	—
V. sp	—	—	—	1.0
Wilsonites vesicatus (Kosanke) Kosanke	.5	—	4.0	—
Monosaccate	—	1.0	—	—
Fungal hyphae	—	—	—	X
Total	100.0	100.0	100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

852-A, 17.0–17.2 m coal, canneloid.
852-B, 17.2–17.4 m carbonaceous shale with clay.
852-C, 17.4–17.5 m coal, dull.
852-D, 17.5–17.6 m shale with vitrain lenses.

GENERIC SUMMARY OF 852-A AND 852-C (in percent)

Cyclogranisporites	4.6
Endosporites	7.0
Laevigatosporites	63.6
Punctatisporites	3.3
Thymospora	12.5
Total	91.0

TABLE 8.—*Holmes Knob diamond drill core, lower Conemaugh Formation*

[Samples from 129.6–130.3 m. Location of hole given in table 7. Macerations 852-I–M, USGS Paleobotanical loc. No. D6842 I–M; X indicates taxon not encountered in count or count not attempted]

Taxon	852-I	852-J	852-K	852-L	852-M
			(percent)		
Apiculatisporis abditus (Loose) Potonié and Kremp	—	0.5	—	—	—
A. cf. *A. latifgranifer* (Loose) Potonié and Kremp	—	—	X	—	—
A. sp	—	—	—	2.0	—
Cadiospora magna Kosanke	—	.5	—	—	—
Calamospora breviradiata Kosanke	—	1.5	X	18.0	—
C. sp	—	3.0	X	4.0	—
Converrucosisporites sp	—	—	—	2.0	—
Convolutispora sp	—	1.0	—	—	X
Crassispora kosankei (Potonié and Kremp) Bharadwaj	—	.5	X	2.0	—
Cyclogranisporites aureus (Loose) Potonié and Kremp	—	—	—	1.0	—
C. cf. *C. minutus* Bharadwaj	—	4.0	—	8.0	3.5
C. multigranus Smith and Butterworth	—	—	X	11.0	—
C. spp	—	4.5	X	—	.5
Dictyotriletes muricatus (Kosanke) Smith and Butterworth	—	1.0	—	—	.5
D. sp	—	1.0	—	—	—
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	—	34.0	—	3.0	—
E. zonalis (Loose) Knox	—	8.5	—	—	—
E. sp	—	1.5	X	—	—
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	—	1.5	—	X	—
F. spp	—	1.5	—	—	.5
Gillespieisporites venustus Clendening	—	.5	X	1.0	3.5
Granulatisporites sp	—	1.0	X	3.0	—
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	X	—	1.0
L. globosus Schemel	—	.5	X	—	—
L. latus Kosanke	—	—	X	—	—
L. medius Kosanke	X	—	X	—	—
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	—	15.5	—	16.0	78.5
L. ovalis Kosanke	—	—	X	X	1.5
L. punctatus Kosanke	—	—	X	2.0	—
L. subovalis sp. nov	—	—	X	—	6.5
L. vulgaris Ibrahim	—	—	—	1.0	—
Leiotriletes adnatus (Kosanke) Kosanke	—	—	—	1.0	—
L. inermis (Waltz) Ischenko	—	—	—	—	X
L. cf. *L. parvus* Guennel	—	—	X	—	—
Lophotriletes cf. *L. granoornatus* Artüz	—	.5	—	—	—
Microreticulatisporites cf. *M. novicus* Bharadwaj	—	1.5	—	—	—
M. sulcatus (Kosanke) Smith and Butterworth	—	—	X	—	—
Punctatisporites minutus (Kosanke) Peppers	—	—	—	X	X
P. spp	X	.5	X	—	1.0
Raistrickia aculeata Kosanke	—	—	X	1.0	—
Reinschospora triangularis Kosanke	—	2.0	—	—	—
Thymospora sp	X	1.5	X	2.0	—
Triquitrites minutus Alpern	—	1.0	—	—	—
T. pulvinatus Kosanke	—	—	X	1.0	—
T. sculptilis (Balme) Smith and Butterworth	—	—	X	—	—
T. spp	—	1.5	X	5.0	1.5
Verrucosisporites donarii Potonié and Kremp	—	1.0	—	—	—
V. sifata (Ibrahim) Smith and Butterworth	—	—	—	—	.5
V. spp	—	4.5	X	2.0	—
Vestispora fenestrata (Kosanke) Spode in Smith and Butterworth	—	—	—	1.0	—
Wilsonites vesicatus (Kosanke) Kosanke	—	1.5	X	7.0	—
W. sp	—	—	—	X	—
Monosaccate	X	2.5	—	5.0	1.0
Fungal	—	—	X	—	—
Unassigned	—	—	—	1.0	—
Total		100.0		100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

852-I, 129.6–129.8 m shale and carbonaceous lenses.
852-J, 129.8–129.9 m coal, impure.
852-K, 129.9–130.1 m coal, impure.
852-L, 130.1–130.2 m coal, impure.
852-M, 130.2–130.3 m shale, carbonaceous.

GENERIC SUMMARY OF 852-J AND 852-L (in percent)

Calamospora	23.2
Cyclogranisporites	14.2
Endosporites	23.5
Laevigatosporites	19.5
Verrucosisporites	3.7
Wilsonites	4.3
Monosaccate	3.7
All other taxa	7.9
Total	100.0

TABLE 9.—*Palynomorphs identified from Pittsburgh No. 8 coal bed, lower Monongahela Formation, in West Virginia*

[Pocatalico 7½-minute quadrangle, macerations 428-A-C, USGS Paleobotanical loc. No. D6043; 750 specimens counted; 0, present but minor percentage of assemblage]

Taxon	428-A	428-B (percent)	428-C
Calamospora hartungiana Schopf in Schopf, Wilson, and Bentall	—	0	—
C. sp	0	—	—
Crassispora kosankei (Potonié and Kremp) Bharadwaj	—	0	—
Cyclogranisporites minutus Bharadwaj	0	—	—
C. cf. *C. multigranus* Smith and Butterworth	0	—	—
C. sp	—	0	0
Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	0	0	0
L. medius Kosanke	3.2	2.0	7.2
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	4.0	2.8	6.0
L. ovalis Kosanke	3.6	3.2	6.4
L. subovalis sp. nov	0	0	0
Pityosporites westphalensis	0	—	—
Punctatisporites cf. *P. obesus* (Loose) Potonié and Kremp	0	—	—
P. spp	—	0	0
Reinschospora magnifica Kosanke	0	—	—
Thymospora thiessenii (Kosanke) Wilson and Venkatachala	84.4	88.0	72.4
Verrucosisporites spp	0	0	0
All other taxa listed by 0 symbol	4.8	4.0	8.0
Total	100.0	100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

428-A, 35.5 cm coal.
428-B, 35.5 cm coal.
428-C, 35.5 cm coal.

GENERIC SUMMARY OF 428-A-C (in percent)

Laevigatosporites	12.8
Thymospora	81.6
All other genera	5.6
Total	100.0

The 92.7-cm-thick Pomeroy or Redstone coal bed occurs about 20 m above the Pittsburgh No. 8 coal bed in the Wolfpen Hollow section. The Wolfpen Hollow section is located slightly less than 1 km northwest of the Divide section from which the samples of the Pittsburgh No. 8 coal bed were taken. Nine samples of seat rock, shale, and coal were collected from the Pomeroy, units 2-4 and unit 8. These samples were assigned to D6796 and macerations 472-A-I as shown in table 10. The coal samples and the roof sample (472-F) yielded abundant palynomorphs. Samples assigned to macerations 472-A and 472-C-E contained palynomorphs, but not in sufficient abundance to warrant abundance counts. The palynomorphs from this coal are similar to those of the Pomeroy coal bed of Ohio (Kosanke, 1943) and to the Redstone coal bed of northern West Virginia (Habib, 1968). *Laevigatosporites*, especially *L. minutus* (Ibrahim) Schopf, Wilson, and Bentall (= *Punctatosporites minutus* Ibrahim), is the dominant taxon with 49 percent of the assemblage. *Laevigatosporites* accounts for 80.9 percent of the palynomorph assemblage. *Thymospora thiessenii*, which is so abundant in the Pittsburgh No. 8 coal bed below, was not identified from the coal samples, although a specimen assignable to the genus was observed in maceration 472-D above the coal. *Secarisporites* cf. *S. crenatus*, described from the Hernshaw Formation of Kentucky by Peppers (1964), was found in maceration 472-D. A specimen of *Cirratriradites* cf. *C. megaspinosus* (Ibrahim) Smith and Butterworth also was observed in maceration 472-D. This coal, the Pomeroy or Redstone, differs from the Pittsburgh No. 8 coal bed in another important aspect and that is diversity of palynomorphs. Twenty-nine genera have been identified from the Pomeroy coal bed, which suggests the floral composition of this coal was much different than that of the Pittsburgh No. 8 coal bed, from which only 9 genera have been identified. Furthermore, *Thymospora thiessenii*, which represents 80 percent of the palynomorph assemblage of the Pittsburgh No. 8 coal bed, was not observed in the Pomeroy coal bed.

An unnamed coal 48.2 cm thick from the Loop section, in the middle-upper part of the Monongahela Formation, just north of the Jackson-Kanawha County line in southern Jackson County along Interstate 77, Sissonville 7½-minute quadrangle, was assigned to D6797 and macerations 538-A-C. Palynomorphs were fairly abundant in these samples, but palynomorph diversity is limited to just 18 genera as shown in table 11. *Laevigatosporites* is most abundant with 67.2 percent of the assemblage assigned to this genus. Three species of *Laevigatosporites* (*L. minutus*, *L. ovalis*, and *L. subovalis*) account for more than half of the palynomorph assemblage in both 538-A and -B, unit 10. This

TABLE 10.—*Palynomorphs from Pomeroy-Redstone coal bed and adjacent strata, lower Monongahela Formation, units 2, 4, and 8, Wolfpen Hollow section*

[Located 0.9 km west-northwest of stop 24, Divide section of Henry and others (1979), Pocatalico 7½-minute quadrangle. Macerations 472-A, -C-I, USGS Paleobotanical loc. No. D6796 A, C-I; X indicates taxon not observed in count or count not attempted]

Taxon	472-A	472-C	472-D	472-E	472-F	472-G	472-H	472-I
				(percent)				
Acanthotriletes	—	X	—	—	—	—	—	—
Anapiculatisporites sp	—	—	X	—	—	—	—	—
Apiculatisporis sp	—	—	X	—	X	—	—	—
Cadiospora cf. *C. magna* Kosanke	—	—	—	—	0.5	—	—	—
Calamospora breviradiata Kosanke	—	—	—	X	4.0	—	—	2.5
C. liquida Kosanke	—	—	—	—	.5	1.0	—	1.0
C. pedata Kosanke	—	—	—	—	—	1.0	—	1.0
C. sp	—	—	X	X	1.5	1.5	2.0	1.5
Cirratriradites cf. *C. megaspinosus* (Ibrahim) Potonié and Kremp	—	—	X	—	—	—	—	—
Convolutispora sp. A (of Clendening)	—	—	—	—	—	1.0	—	—
Cyclogranisporites aureus (Loose) Potonié and Kremp	—	—	X	X	—	—	—	—
C. multigranus Smith and Butterworth	X	X	—	—	X	1.0	—	—
C. obliquus (kosanke) Upshaw and Hedlund	X	—	—	—	—	—	1.5	—
C. sp	—	X	—	—	—	—	—	—
Dictyotriletes sp	—	X	—	—	—	—	—	—
Endosporites globiformis (Ibrahim) Schopf, Wilson, and Bentall	X	—	—	—	.5	—	—	—
E. sp	X	—	—	—	.5	—	—	—
Fabasporites sp	—	—	—	—	X	2.0	—	—
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	—	—	X	—	X	X	—	—
F. sp	—	—	X	—	—	—	—	—
Gillespieisporites venustus Clendening	—	X	—	X	2.5	1.0	1.5	.5
Granulatisporites cf. *G. minutus* Potonié and Kremp	—	—	—	—	—	—	—	X
G. sp	—	—	—	X	1.0	—	—	X
Laevigatosporites clendeningii sp. nov	—	—	—	—	—	—	—	X
L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	X	—	1.0	2.0	—	—
L. dunkardensis Clendening	—	—	—	—	2.0	2.0	.5	X
L. latus Kosanke	—	—	X	—	X	X	5.5	2.0
L. minimus (Wilson and Coe) Schopf, Wilson, and Bentall	X	X	—	—	.5	—	2.0	X
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	X	X	X	—	76.0	33.0	48.0	78.0
L. ovalis Kosanke	—	—	X	X	9.0	13.5	11.0	3.0
L. subovalis sp. nov	—	—	X	X	X	15.5	24.0	9.5
L. vulgaris Ibrahim	—	X	—	—	—	1.0	—	—
Leiotriletes adnatus (Kosanke) Potonié and Kremp	X	X	X	—	—	1.5	—	—
Microreticulatisporites sulcatus (Wilson and Kosanke) Smith and Butterworth	—	—	—	—	—	—	.5	—
M. sp	—	—	—	—	—	—	1.5	—
Murospora kosankei Somers	—	—	—	—	—	—	—	X
Pityosporites westphalensis Williams	—	—	—	—	—	—	1.0	—
Punctatisporites minutus (Kosanke) Peppers	—	X	—	—	.5	.5	—	—
P. parvipunctatus Kosanke	X	—	—	—	—	—	—	—
Raistrickia aculeata Kosanke	—	—	—	—	—	—	X	X
R. sp	—	—	—	—	—	—	.5	—
Reinschospora cf. *R. triangularis* Kosanke	—	—	—	—	—	2.0	.5	—
Schopfipollenites sp	—	—	—	—	—	X	—	—
Secarisporites cf. *S. crenatus* Peppers	—	—	X	—	—	—	—	—
Thymospora sp	—	—	X	—	—	—	—	—
Triquitrites minutus Alpern	—	—	X	—	X	19.0	—	—
T. sp	—	—	—	—	—	X	—	—
Verrucosisporites donarii Potonié and Kremp	—	X	X	—	—	—	—	—
V. sp	—	X	—	—	—	X	—	—
Vestispora wilsonii (Schemel) Wilson	—	X	X	—	X	1.0	—	X
Wilsonites vesicatus (Kosanke) Kosanke	—	—	—	X	—	—	X	—
Monosaccate	—	—	—	—	—	1.0	—	—
Septate hyphae	—	—	—	—	—	—	X	—
Unassigned	X	X	X	X	X	—	—	X
Total					100.0	100.0	100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

472-A, 2.4 cm seat rock, unit 2.
472-B, 9.1 cm claystone (barren).
472-C, 15.2 cm shale, unit 4.
472-D, 15.2 cm seat rock, unit 8.
472-E, 5.5 cm above base, unit 8.
472-F, 0.6 cm seat rock, unit 8.
472-G, 41.1 cm coal, unit 8.
472-H, 26.4 cm coal, unit 8.
472-I, 25.2 cm coal, unit 8.

GENERIC SUMMARY OF 472-G-I (in percent)

Calamospira	3.8
Laevigatosporites	80.9
Triquitrites	8.4
Total	93.1

is also true of the seat rock sample, 538-C, unit 9. *Thymospora parva* sp. nov., which was first identified from the Wallace Heights School section, maceration 565, occurs in the seat rock sample of 538. *Crassispora kosankei* constitutes 8.5 percent of the assemblage in 538-A, and *Vesicaspora wilsonii* represents 8 percent of the assemblage in 538-B. The unnamed coal bed of the Loop section is somewhat similar to the coal bed below in the 472 maceration series but with differences in abundance of the species of *Laevigatosporites* and with greater numerical importance of *Crassispora* and *Vesicaspora*. The taxa identified in the 538 maceration series are given in table 11.

A series of samples were collected from the Devils Den Hollow section, including units 5, 6, 15, 16, 17, 27, and 28. Units 5, 6, 17, 27, and 28 were barren of palynomorphs.

A very limited assemblage of palynomorphs was recovered from unit 15, and the samples were assigned to D6938 and macerations 510-A-C. These samples

TABLE 11.—*Palynomorphs from a roadcut of Interstate 77, Loop section, units 9 and 10, in the middle-upper part of the Monongahela Formation*

[Sissonville 7½-minute quadrangle, Jackson County, W. Va. Macerations 538-A-C, USGS Paleobotanical loc. No. D6797 A-C; 600 specimens counted; X indicates presence of taxon]

Taxon	538-A	538-B (percent)	538-C
Calamospora pedata Kosanke	—	—	0.5
C. sp	3.0	—	.5
Convolutispora sp	—	—	.5
Crassispora kosankei (Potonié and Kremp) Bharadwaj	8.5	—	1.0
Cyclogranisporites spp	2.5	—	5.0
Florinites spp	—	5.0	2.0
Gillespieisporites venustus Clendening	1.5	2.0	.5
Granulatisporites minutus Potonié and Kremp	.5	—	—
Laevigatosporites clendeningii sp. nov	5.5	—	2.0
L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	4.5	7.0	5.0
L. latus Kosanke	1.0	—	—
L. medius Kosanke	4.5	7.0	11.0
L. minimus (Wilson and Coe) Schopf, Wilson, and Bentall	X	2.0	1.0
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	26.0	14.0	18.0
L. ovalis Kosanke	15.5	17.0	11.0
L. subovalis sp. nov	11.0	18.0	24.0
L. vulgaris Ibrahim	1.5	—	.5
Leiotriletes sp	—	—	1.0
Lophotriletes cf. *L. gibbosus* (Ibrahim) Potonié and Kremp	—	—	8.5
Microreticulatisporites sp	1.5	—	—
Pityosporites westphalensis Williams	.5	5.0	2.0
Punctatisporites sp	1.0	1.5	.5
Raistrickia aculeata Kosanke	1.0	—	—
R. sp	1.0	—	1.0
Thymospora parva sp. nov	—	—	.5
T. sp. 1	—	—	X
Triquitrites minutus Alpern	1.0	—	—
T. sp	—	—	.5
Vesicaspora wilsonii (Schemel) Wilson	2.0	8.0	1.0
Verrucosisporites donarii Potonié and Kremp	.5	—	—
V. microtuberosus (Loose) Smith and Butterworth	3.5	—	.5
V. cf. *V. verrucosus* (Ibrahim) Ibrahim	—	4.0	—
V. sp	2.0	—	—
Wilsonites vesicatus (Kosanke) Kosanke	—	—	2.0
Monosaccate	.5	9.0	—
Septate hyphae	—	.5	—
Unassigned	X	—	—
Total	100.0	100.0	100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

538-A, 24.1 cm coal, unit 10.
538-B, 24.1 cm coal, unit 10.
538-C, 10.1 cm seat rock, unit 9.

GENERIC SUMMARY OF 538-A-B (in percent)

Crassispora	4.2
Laevigatosporites	67.2
Vesicaspora	5.0
Total	76.4

were from thin, carbonaceous, and coaly clay. Only nine genera were identified and abundance counts were not possible. The presence of *Striatites*, *Thymospora parva* sp. nov., and some bisaccates certainly indicates an important change in the palynomorph assemblage. The palynomorphs identified from unit 16 of the Devils Den Hollow section are listed in table 12.

Samples of the Waynesburg coal bed of Krebs (1911) were collected from unit 16 of the Devils Den Hollow section, Kenna 7½-minute quadrangle, and assigned to macerations 511-A-E. Five samples were collected from 19.6 cm of coal, 4.4 cm of seat rock, 1.3 cm of coal, and 0.6 cm of seat rock (511-E) which was barren of palynomorphs. This coal bed is at the Pennsylvanian-Permian boundary and is a mixture of dull coal and clay. Maceration 511-C is a seat rock sample, and only five species of *Laevigatosporites* were found in this sample. Eighty percent of the specimens counted in the coal samples, 511-A-B and 511-D, were assignable to *Laevigatosporites*. *Calamospora* and *Cyclogranisporites* account for more than 5 and 3 percent, respectively, of these coal samples. The species of *Laevigatosporites* represent a mixture of those assignable to ferns and the sphenopsids. The assemblage of palynomorphs identified from this coal bed does not suggest proximity to the Permian Period as is known from elsewhere in the United States and thus, in part supports the idea of a transition rather than an abrupt change between the Pennsylvanian and Permian Periods in the Eastern United States. The palynomorphs identified from the 511 maceration series are listed in table 13.

Samples of the Waynesburg "A" coal bed of Krebs (1911) were collected from a tributary of Painters Branch near Liberty, Putnam County, and assigned to the 644 maceration series. At this locality, a roof sample and five coal samples were collected. The coal was 68.4 cm thick, and all samples yielded abundant and well-preserved palynomorphs. *Laevigatosporites* accounted for more than 55 percent of the palynomorph assemblage of the coal samples, *Thymospora parva* sp. nov. accounted for 26.5 percent, and *Fabasporites* accounted for 8.7 percent. *Thymospora parva* represents more than 36 percent of the palynomorph assemblage of the bottom three coal samples (644-D-F) as shown in table 14. *Tuberculatosporites* cf. *T. robustus* (Kosanke) Peppers is present in the bottom coal sample (644-F) but not in any other samples of the 644 maceration series. *Fabasporites* is most abundant in the roof and top coal samples (644-A-B). *Laevigatosporites subovalis* sp. nov. is the most abundant species in this maceration series. Twenty-six genera have been recognized from these samples as shown in table 14.

Clendening (1974) in his report on the Dunkard Group palynomorphs from the Appalachians indicated his samples from the Cassville Shale Member of the Washington Formation had *Thymospora* sp. A, which I have described formally in this report as *Thymospora parva*. This taxon is abundant in the 644 maceration series. Clendening (1974) also reported this taxon was present in the Waynesburg "A" coal bed but only to the extent of probably less than 1 percent. However, this taxon is more abundant in his Waynesburg "B" coal bed. Because the Cassville Shale Member stratigraphically occurs below the Waynesburg Sandstone Member, it is possible that maceration series 644 from the stratotype is more closely related to Clendening's Waynesburg "B" samples. Some additional work at this stratigraphic interval needs to be done to resolve this relationship.

The position of the Pennsylvanian-Permian boundary in the northern Appalachians was initially placed between the Waynesburg coal bed and the Cassville Shale. The basis for this placement was the presence of *Callipteris conferta* in the Cassville Shale. The position of this boundary has been debated for many years. Part of the lower portion of the Dunkard Formation between the Waynesburg and Washington coal beds has been considered late Pennsylvanian and early Permian. In the area of the proposed Pennsylvanian System stratotype, this boundary was placed near the "Waynesburg" Sandstone by Henry, Lyons, and Windolph (1979) and more recently on the top of the Waynesburg Sandstone of Krebs (1911) by Englund and others (1986).

Clendening (1974) collected 115 samples from throughout the Dunkard for palynological analysis. He

TABLE 12.—*Palynomorphs from upper Monongahela Formation, unit 15 of Devils Den Hollow section*

[Kenna 7½-minute quadrangle, Jackson County, W. Va. Macerations 510-A-C, carbonaceous and coaly clay, USGS Paleobotanical loc. No. D6938 A-C; X indicates presence of taxon]

Taxon	510-A	510-B	510-C
Calamospora sp	X	—	—
Cyclogranisporites sp	X	—	—
Crassispora kosankei	—	X	—
Dictyotriletes sp	X	—	—
Laevigatosporites minutus (Ibrahim) Schopf, Wilson, and Bentall	X	—	—
L. ovalis Kosanke	X	—	X
Microreticulatisporites	X	—	—
Punctatisporites sp	—	—	X
Striatites cf. *S. splendens* (Jizba) Tschudy and Kosanke	—	—	X
Thymospora parva sp. nov	X	—	—
Monosaccate	X	X	X
Bisaccate	X	X	—

DESCRIPTION OF MATERIAL IN MACERATIONS

510-A, 3.8 cm carbonaceous clay.
510-B, 1.9 cm carbonaceous clay.
510-C, 1.9 cm coaly clay.

TABLE 13.—*Palynomorphs from the Waynesburg coal bed of Krebs (1911), upper Monongahela Formation, unit 16 of Devils Den Hollow section*

[Kenna 7½-minute quadrangle, Jackson County, W. Va. Macerations 511-A-E, USGS Paleobotanical loc. No. D6938; X indicates taxon not observed in count or count not attempted]

Taxon	511-A	511-B	511-C	511-D
	(percent)			
Calamospora breviradiata Kosanke	10.0	X	—	1.0
C. hartungiana Schopf in Schopf, Wilson, and Bentall	X	1.0	—	—
C. sp	3.0	4.0	—	1.0
Convolutispora sp	—	.5	—	—
Cyclogranisporites minutus Bharadwaj	2.5	—	—	.5
C. multigranus Smith and Butterworth	3.0	—	—	—
C. spp	.5	.5	—	1.0
Gillespieisporites venustus Clendening	—	2.0	—	—
Granulatisporites granulatus Ibrahim	.5	—	—	—
Florinites cf. *F. antiquus* Schopf in Schopf, Wilson, and Bentall	.5	—	—	—
Laevigatosporites clendeningii sp. nov	X	3.0	—	—
L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	8.0	6.5	X	14.0
L. globosus Schemel	3.5	.5	—	.5
L. latus Kosanke	1.0	X	X	1.0
L. medius Kosanke	9.5	5.0	X	19.0
L. minimus (Wilson and Coe) Schopf, Wilson, and Bentall	—	1.0	—	—
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	20.0	14.0	X	1.5
L. ovalis Kosanke	19.5	7.0	—	31.0
L. punctatus Kosanke	1.0	—	—	1.5
L. subovalis sp. nov	10.0	50.0	X	19.0
L. vulgaris Ibrahim	.5	3.0	—	X
Leiotriletes sp	.5	X	—	—
Pityosporites westphalensis Williams	1.0	X	—	2.5
Punctatisporites minutus (Kosanke) Peppers	—	—	—	3.5
P. spp	2.0	—	—	.5
Raistrickia aculeata Kosanke	—	X	—	—
Verrucosisporites sp	.5	—	—	—
Vesicaspora wilsonii (Schemel) Wilson	1.5	1.0	—	.5
Wilsonites vesicatus (Kosanke) Kosanke	—	—	—	1.0
Monosaccate	.5	—	—	.5
Unassigned	1.0	1.0	—	.5
Total	100.0	100.0		100.0

DESCRIPTION OF MATERIAL IN MACERATIONS

511-A, 11.4 cm dull coal.
511-B, 8.2 cm dull coal and seat rock mixed.
511-C, 4.4 cm seat rock.
511-D, 1.3 cm coal.
511-E, 0.6 cm coaly seat rock (barren).

GENERIC SUMMARY OF 511-A-B AND 511-D (in percent)

Calamospora	5.7
Cyclogranisporites	3.5
Laevigatosporites	80.5
Total	89.7

concluded, "Palynological evidence, therefore, supports assignment of the entire Dunkard Group to the Pennsylvanian System."

In the current investigation, samples of the Waynesburg coal bed of Krebs (1911) and what was considered to be the Waynesburg "A" coal bed of Krebs (1911) were examined. These two coal beds stratigraphically occur below and above, respectively, the Waynesburg Sandstone of Krebs (1911). The Waynesburg "A" coal bed can be differentiated from the Waynesburg coal bed by an abundance of *Thymospora parva* sp. nov. in the Waynesburg "A" coal bed. However, Clendening (1974) found only a few specimens of this taxon in one of his samples of the Waynesburg "A" coal bed, whereas he found it abundant in the Cassville Shale below and the Waynesburg "B" coal bed above.

Palynomorphs from Permian strata of the Midcontinent of the United States contain abundant and morphologically diverse saccate types as reported by Wilson (1962), Jizba (1962), Tschudy and Kosanke (1966), and others. Clendening (1974) reported only a very limited number of such taxa from the Dunkard Formation. The differences in palynomorph assemblages between the two areas may very well attest to differences in climatic conditions.

DESCRIPTION OF NEW SPECIES

A number of new taxa were observed during this investigation of the palynomorphs of the Upper Pennsylvanian Series, but most of these taxa were of

TABLE 14.—*Palynomorphs from Waynesburg "A" coal bed of Krebs (1911), lower Dunkard Formation from outcrop in left-hand tributary of Painters Branch*

[Located 63.9 m north-northeast of bench mark 776 at Liberty, Sissonville 7½-minute quadrangle, Putnam County, W. Va. Macerations 644-A-F, USGS Paleobotanical loc. No. D6842 A-F; X indicates taxon not observed in count]

Taxon	644-A	644-B	644-C	644-D	644-E	644-F
			(percent)			
Cadiospora cf. *C. magna* Kosanke	—	—	—	0.5	—	—
Calamospora breviradiata Kosanke	1.5	2.0	0.5	—	—	0.5
C. liquida Kosanke	—	—	.5	—	—	—
C. cf. *C. pallida* (Loose) Schopf, Wilson, and Bentall	—	—	—	1.0	—	—
C. pedata Kosanke	.5	—	—	—	—	—
C. sp	.5	—	3.0	—	—	.5
Convolutispora	—	—	—	—	—	X
Cyclogranisporites aureus (Loose) Potonié and Kremp	1.5	.5	—	—	—	.5
C. sp	1.0	—	1.0	0.5	0.5	—
Fabasporites spp	28.0	26.0	1.0	2.5	4.5	6.0
Florinites antiquus Schopf in Schopf, Wilson, and Bentall	—	—	.5	—	—	—
Gillespieisporites venustus Clendening	—	X	.5	1.0	1.0	X
Granulatisporites granulatus Ibrahim	.5	—	—	—	.5	—
Laevigatosporites clendeningii sp. nov	—	—	X	1.5	.5	1.0
L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall	2.0	.5	2.5	4.0	1.5	6.0
L. dunkardensis Clendening	—	X	2.0	X	—	X
L. latus Kosanke	—	2.0	4.0	1.0	—	—
L. medius Kosanke	11.0	13.5	17.5	3.0	5.5	2.0
L. minimus (Wilson and Coe) Schopf, Wilson, and Bentall	—	—	X	4.0	3.0	3.0
L. minutus (Ibrahim) Schopf, Wilson, and Bentall	15.0	11.5	4.5	5.0	8.0	10.0
L. ovalis Kosanke	6.0	7.5	13.5	5.0	8.0	2.0
L. subovalis sp. nov	23.5	26.0	34.0	25.0	25.0	23.5
L. vulgaris Ibrahim	—	.5	1.0	1.5	1.5	1.0
Leiotriletes sp	—	—	—	.5	—	—
Microreticulatisporites sp	—	—	.5	—	—	—
Pityosporites westphalensis Williams	—	1.5	4.0	2.5	—	—
Punctatisporites sp	.5	X	—	—	—	1.5
Pustulatisporites(?)	—	—	—	—	—	X
Raistrickia saetosa (Loose) Schopf, Wilson, and Bentall	—	—	.5	—	—	—
R. sp	—	—	—	—	—	X
Reticulatisporites sp	.5	—	—	—	—	—
Schopfipollenites cf. *S. ellipsoides* (Ibrahim) Potonié and Kremp	—	—	—	—	X	—
Thyomospora parva sp nov	6.5	7.5	10.0	36.0	36.5	39.5
Trihyphaecites(?)	—	—	—	—	—	.5
Triquitrites minutus Alpern	—	.5	—	—	—	1.0
Tuberculatosporites cf. *T. robustus* Kosanke) Peppers	—	—	—	—	—	X
Verrucosisporites microtuberosus (Loose) Smith and Butterworth	—	—	—	1.5	2.9	1.5
V. verrucosus (Ibrahim) Ibrahim	—	—	—	2.0	—	—
V. sp	—	.5	—	2.0	1.0	—
Vesicaspora wilsonii (Schemel) Wilson	X	X	—	—	—	—
Monosaccate	.5	—	—	—	—	—
Bisaccate	1.0	—	—	—	—	—
Septate hyphae	—	—	—	X	—	—
Unassigned	—	—	—	—	1.0	—
Total	100.0	100.0	100.0	100.0	100.0	100.0

DESCRIPTION OF MATERIALS IN MACERATIONS

644-A, 15.2 cm roof. 644-D, 15.2 cm coal.
644-B, 15.2 cm coal. 644-E, 15.2 cm coal.
644-C, 7.6 cm coal. 644-F, 15.2 cm coal.

GENERIC SUMMARY OF 644-B-F (in percent)

Fabasporites	8.7
Laevigatosporites	56.1
Thymospora	26.5
Total	91.3

extremely limited occurrence. Some of these are recorded as species or as unassigned; however, three species occur in sufficient numbers to justify formal treatment.

Genus LAEVIGATOSPORITES

Type species.—*L. vulgaris* (Ibrahim) Schopf, Wilson, and Bentall.

Laevigatosporites clendeningii sp. nov.

Holotype.—USGS Paleobotanical loc. No. D6841-D, maceration 644-D, slide 6 coordinates 121.4×11.9, negative 5235, plate 2, figure 6.

Paratypes.—Clendening, 1974, plate 11, figures 4 and 5.

Species description.—Monolete, broadly bilateral. Aperture as long as two-thirds spore length. Levigate spore coat characteristically folded. Overall size varies from about 85 to 110 microns. Width of spore is about 80 percent of spore length.

Discussion.—This taxon is readily recognized by its broad body, folding of the spore coat, and large size. Clendening (1974) observed this taxon in his study of the palynomorphs of the Dunkard Group and called it *Laevigatosporites* sp. A. He found this taxon in the Washington coal and older strata of the Dunkard Group with a single occurrence much higher in the section. In the present study, I have identified this taxon from the upper Conemaugh, maceration series 565, to the Waynesburg "A" coal bed of Krebs (1911). I have named this taxon in honor of John A. Clendening.

Laevigatosporites subovalis sp. nov.

Holotype.—USGS Paleobotanical loc. No. D6841-A, maceration 644-A, slide 4, coordinates 107.7×20.3, negative 5253, plate 2, figure 5. Maceration series 644 is the Waynesburg "A" coal bed of Krebs (1911).

Species description.—Monolete, broadly bilateral, somewhat oval in outline. Aperture with fairly thick lips as long as two-thirds the length of the spore. The width of the spore is as much as 75 percent of spore length. Spore coat is levigate.

Discussion.—This taxon is strikingly similar to *L. ovalis* Kosanke except it is significantly smaller in overall dimensions. About 25 specimens were measured; the length varies from 34 to 44 microns, and the width varies from 26 to 31 microns. *L. ovalis* is generally much larger; the previously known size range is from 45 to 65 microns. *L. subovalis* is much larger than either *L. minimus* (Wilson and Coe) Schopf, Wilson, and Bentall or *L. minutus* (Ibrahim) Schopf, Wilson, and Bentall. This new species is much broader than *L. medius* Kosanke. *L. subovalis* occurs throughout the Upper Pennsylvanian Series and is common in the Waynesburg "A" coal bed of Krebs (1911).

Genus THYMOSPORA Wilson and Venkatachala

Type species.—*T. thiessenii* (Kosanke) Wilson and Venkatachala.

Thymospora parva sp. nov.

Holotype.—USGS Paleobotanical loc. No. D6842-A, maceration 644-A, slide 4, coordinates 114.0 × 5.5, negatives 5232 and 5262, plate 2, figures 14 and 15.

Paratype.—Clendening, 1974, plate 20, figure 11.

Species description.—Monolete, broadly bilateral. Aperture as long as one-half spore length. Spore coat sharply ornamented with very fine grana or elongate elements which form extremely fine verrucate surface. A number of specimens varied in length from 13 to 24 microns. Body width is more than three-fourths the length of the spore. This new species was first observed in maceration series 565 in the Conemaugh Formation and again in maceration series 538 of the Monongahela Formation. The species becomes numerically important in the Waynesburg "A" coal bed of Krebs (1911) in the basal part of the Dunkard Group.

Discussion.—Clendening (1974) illustrated and described this taxon, but did not formally name it. He designated it as *Thymospora* sp. A, and he reported it to be present in his study of the palynomorphs of the Dunkard Group. He reported this species to have numberical importance from the Cassville Shale Member of the Washington Formation to and including the Washington "Rider" coal bed. This taxon is readily differentiated from *T. thiessenii*, *T. pseudothiessenii*, and *T. obscura* based primarily on ornamentation which is extremely fine compared to the other species.

Thymospora sp. 1

Discussion.—*Thymospora* sp. 1 (pl. 2, fig. 16) is distinct from *T. parva* sp. nov. (pl. 2, fig. 14 and 15) and *T. thiessenii* (pl. 2, fig. 13). This separation is based on the degree of ornamentation. Of these three taxa, *T. thiessenii* has the coarsest ornamentation, *T.* sp. 1 has the next coarsest, and *T. parva* sp. nov. has very fine ornamentation. *T.* sp. 1 is limited in occurrence and restricted in distribution to maceration series 565 in the upper part of the Conemaugh Formation.

SUMMARY

The contact between the Charleston Sandstone and the Conemaugh Formation in the stratotype is

gradational (Englund and others, 1986). The Middle-Upper Pennsylvanian Series boundary is placed at the base of a dark-greenish-gray shale. Where present in the northern Appalachians, the Upper Freeport coal bed is the uppermost stratigraphic unit of the Allegheny Formation; however, this coal bed is not present in the proposed stratotype area. The Conemaugh Formation of the stratatype contains some thin, impure, unnamed coal beds; Windolph (1987) questionably assigned names to two of these beds. In some areas of West Virginia and in western Pennsylvanian and Ohio, a number of well-defined, named coal beds are present.

Preservation of palynomorphs from the Conemaugh Formation of the stratotype is, in general, poor compared with other areas in the northern Appalachians, but sufficient samples spanning the formation have been obtained to provide good stratigraphic coverage as shown in figure 3. *Lycospora* spp., *Torispora securis*, and *Thymospora pseudothiessenii* are absent from the first Conemaugh sample (maceration 502-C). In Ohio, these three taxa occur in the Mahoning coal bed, which is the lowermost coal bed of the Conemaugh Formation, but are not present in the next higher coal bed, the Brush Creek coal bed. Furthermore, the range zone of the fusulinid genus *Triticites* in Ohio starts with the Brush Creek Limestone. Thus, a major change in the flora occurs in the lower part of the Conemaugh Formation of the proposed stratotype, and in both flora and fauna of Ohio. Up section, *Endosporites* becomes the most abundant taxon as *Laevigatosporites* declines in abundance in maceration series 504 as shown in figure 3. DiMichele and others (1979) considered the parentage of *Endosporites* to be a heterosporus herbaceous lycopod. The first-observed specimens of *Thymospora thiessenii* were in maceration series 565 in the upper part of the Conemaugh Formation. A number of authors have reported the affinity of this taxon to be with the eusporangiate Marattiales. In general, it is considered that the small-sized species of *Laevigatosporites* have affinities with the ferns. For this reason, the abundances of *L. minutus* and *L. globosus* are shown in figure 3.

The epibole of *Thymospora thiessenii* is the Pittsburgh No. 8 coal bed. Thiessen and Staud (1923) first discussed the importance of this taxon in the recognition of the Pittsburgh coal bed. Overall, *Laevigatosporites* dominates the balance of the Monongahela coal beds as shown in figure 3. *Thymospora parva* sp. nov. was first observed in maceration series 565 in the upper part of the Conemaugh Formation and is an important taxon of the Waynesburg "A" coal bed of Krebs (1911) in the basal part of the Dunkard Formation.

Three species are described as new because they occur with reasonable regularity and play an important role in the assemblages of the Upper Pennsylvanian Series of the stratotype. These are *Laevigatosporites subovalis* sp. nov., *L. clendeningii* sp. nov., and *Thymospora parva* sp nov.

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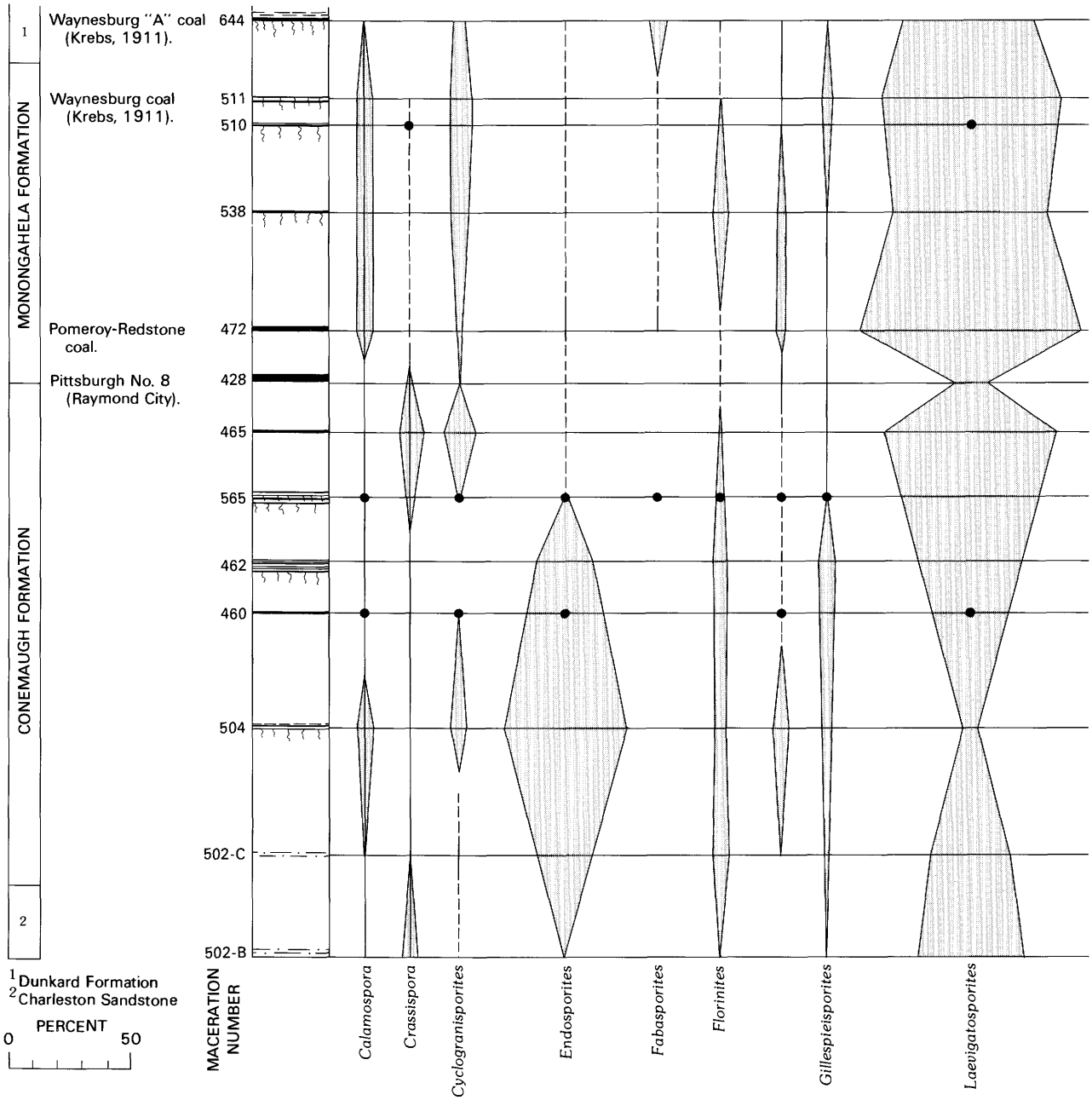

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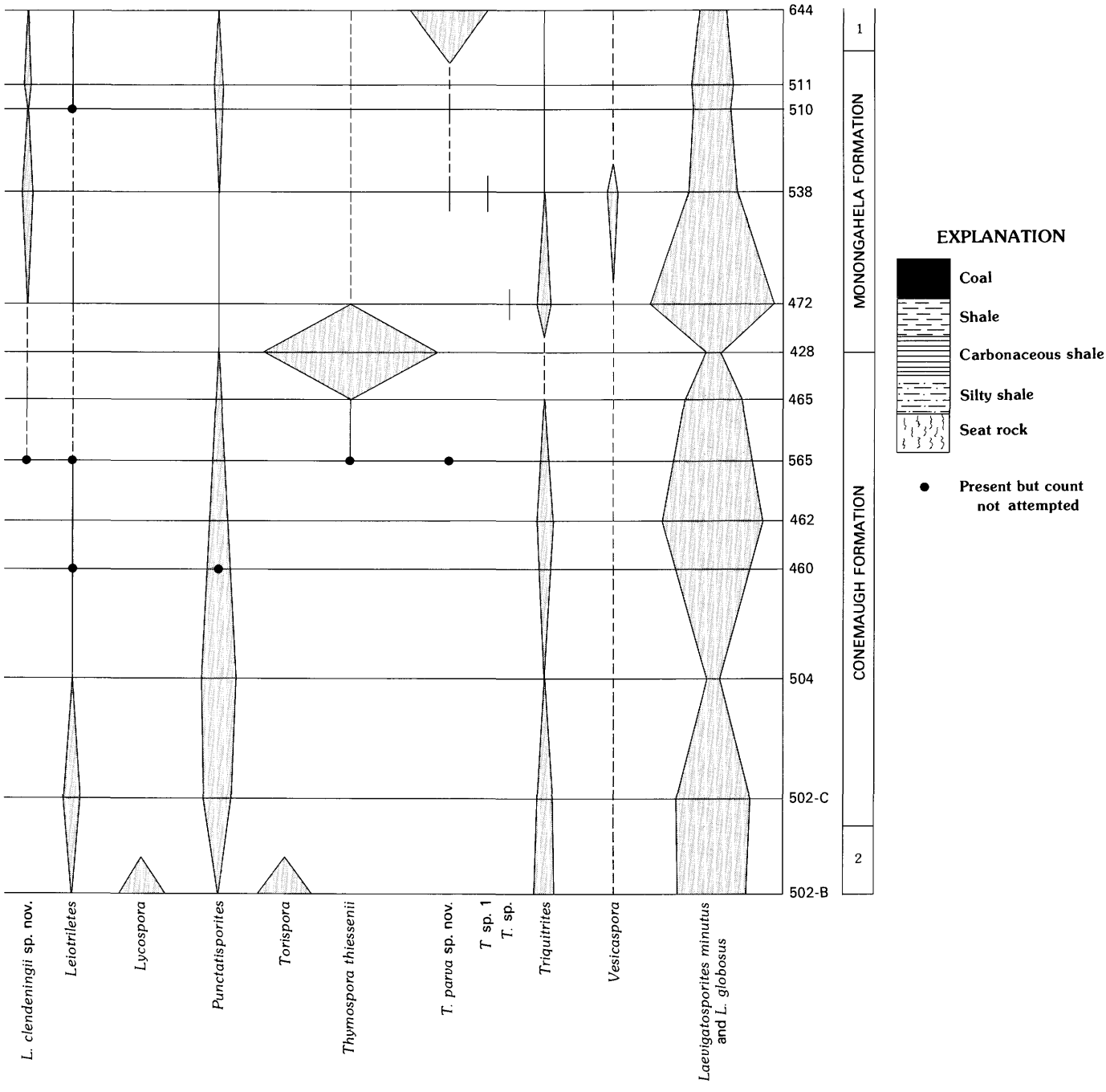

FIGURE 3 (above and facing page).—Distribution and abundance of selected palynomorphs identified from the Conemaugh and Monongahela Formations of the proposed Pennsylvanian System stratotype of West Virginia. Also shown are the palynomorphs from a sample from the Charleston Sandstone and a sample from the lower Dunkard Formation. *Lycospora* spp. and *Torispora securis* are not present in the Conemaugh Formation. *Endosporites*, mostly *E. globiformis*, is abundant in the middle part of the Conemaugh Formation at the expense of *Laevigatosporites* spp., which is dominant from the upper Conemaugh Formation throughout the Monongahela with one exception. This one exception is the Pittsburgh No. 8 coal bed which is the epibole of *Thymospora thiessenii*. *Thymospora parva* sp. nov. accounts for more than one-fourth of the palynomorph assemblage in maceration series 644 at the base of the Dunkard Formation. The data for *Laevigatosporites minutus* and *L. globosus*, shown to the right, have been taken from *L.* spp., shown in the middle. These taxa, as well as several other small-sized species of *Laevigatosporites*, are considered to be related to the ferns.

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PLATES 1-3

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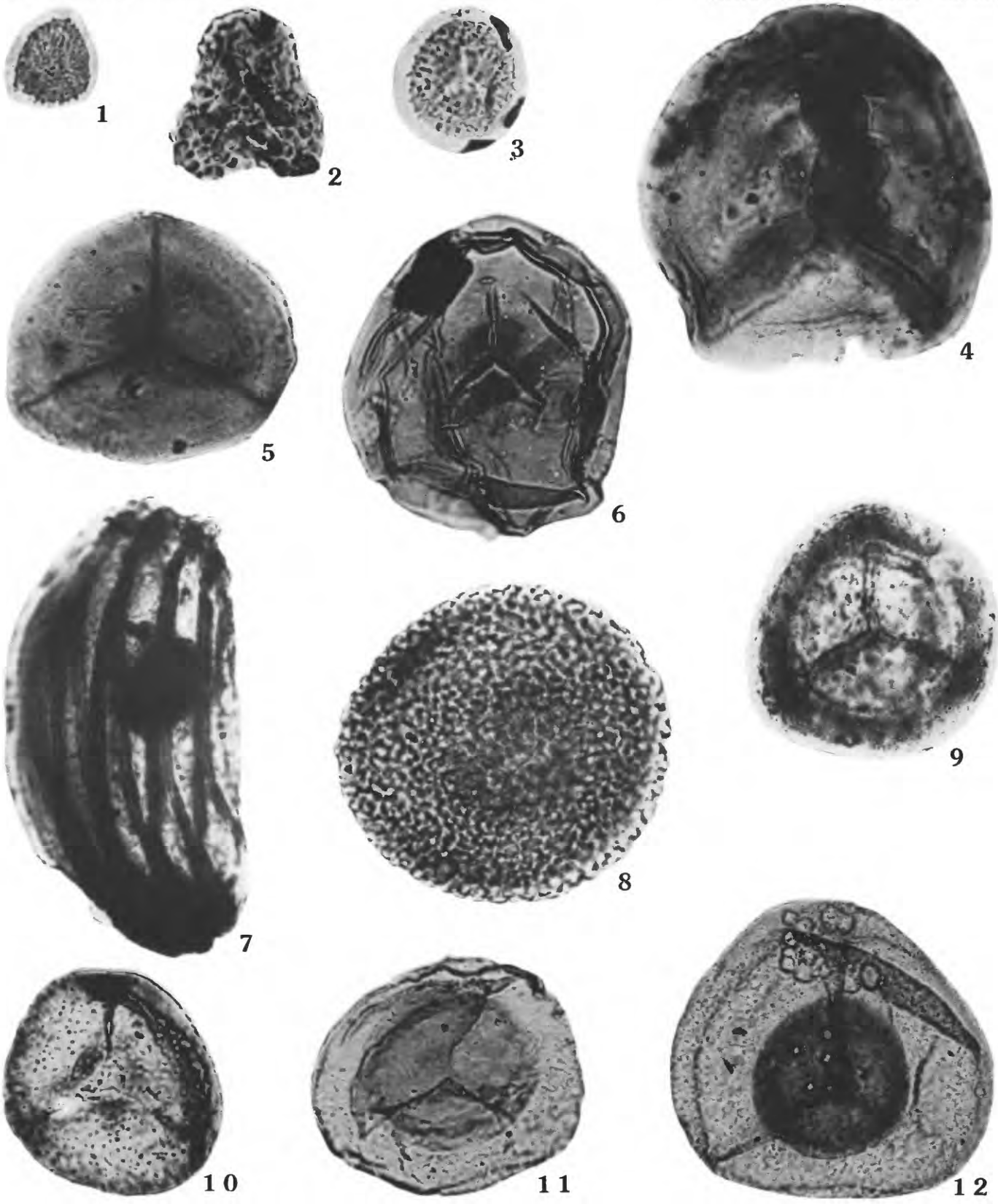
PLATE 1

FIGURES

1. *Acanthotriletes* (?), USGS Paleobotanical loc. No. D6842–B, carbonaceous shale, maceration 852–B, slide 7, coordinates 108.4×5.7, negative 5263. The specimen has a maximum diameter of 28.1 microns.
2. *Acanthotriletes* sp. USGS Paleobotanical loc. No. D6795–D, seat rock, maceration 462–B, slide 1, coordinates 98.5×4.6, negative 5278. The specimen has a maximum diameter of 45 microns.
3. *Apiculatisporis* sp. USGS Paleobotanical loc. No. D6842–C, coal, maceration 852–C, slide 2, coordinates 111.1×19.3, negative 5215. The specimen has a maximum diameter of 31.2 microns.
4. *Cadiospora magna* Kosanke, USGS Paleobotanical loc. No. D6798–J, coal, maceration 565–J, slide 4, coordinates 118.9×11.2, negative 5245. The specimen has a maximum diameter of 91.8 microns.
5. *Angulisporites splendidus* Bharadwaj, USGS Paleobotanical loc. No. D6795–F, coal, maceration 462–F, slide 1, coordinates 107.2×2.0, negative 5207. The specimen has a maximum diameter of 70 microns.
6. *Calamospora breviradiata* Kosanke, USGS Paleobotanical loc. No. D6796–F, seat rock, maceration 472–F, slide 1, coordinates 99.3×16.8, negative 5290. The specimen has a maximum diameter of 77.5 microns.
7. *Culuminisporites* sp. USGS Paleobotanical loc. No. D6842–B, shale, maceration 852–B, slide 7, coordinates 106.4×2.0, negative 5165. The specimen has a maximum diameter of 106.2 microns.
8. *Convolutispora* sp. 1, USGS Paleobotanical loc. No. D6842–J, coal, maceration 852–J, single grain, coordinates 104.0×12.2, negative 5147. The specimen has a maximum diameter of 81.2 microns.
9. *Cirratriradites* cf. *C. megaspinosus* (Ibrahim) Smith and Butterworth, USGS Paleobotanical loc. No. D6796–D, seat rock, maceration 472–D, slide 5, coordinates 117.3×23.3, negative 5318. The specimen has a maximum diameter of 60 microns.
10. *Crassispora kosankei* (Potonié and Kremp) Bharadwaj, USGS Paleobotanical loc. No. D6797–C, seat rock, maceration 538–C, slide 1, coordinates 107×16.4, negative 5331. The specimen has a maximum diameter of 50 microns.
11. *Endosporites zonalis* (Loose) Knox, USGS Paleobotanical loc. No. D6842–J, coal, maceration 852–J, slide 2, coordinates 122.1×19.2, negative 5224. The specimen has a maximum diameter of 82.5 microns.
12. *Endosporites globiformis* (Ibrahim) Schopf, Wilson, and Bentall, USGS Paleobotanical loc. No. D6842–J, coal, maceration 852–J, slide 2, coordinates 117.1×14.3, negative 5150. The specimen has a maximum diameter of 106.2 microns.



ACANTHOTRILETES, APICULATISPORIS, CADIOSPORA, ANGULISPORITES, CALAMOSPORA, CULUMINISPORITES, CONVOLUTISPORA, CIRRATRIRADITES, CRASSISPORA, AND *ENDOSPORITES*

PLATE 2

FIGURES

1. *Gravisporites* cf. *G. sphaerus* (Butterworth and Williams) Bharadwaj, USGS Paleobotanical loc. No. D6842–D, maceration 852–J, slide 1, coordinates 124.0×22.8, negative 5210. The specimen has a maximum diameter of 78.7 microns.

2–3. *Gillespieisporites venustus* Clendening, both specimens from USGS Paleobotanical loc. No. D6796–H, coal, maceration 472–H. Figure 2, slide 1, coordinates 109.6×13.9, negative 5296; maximum diameter is 63.6 microns. Figure 3, slide 6, coordinates 105.9×16.3, negative 5298; maximum diameter is 76.2 microns.

4. *Laevigatosporites medius* Kosanke, USGS Paleobotanical loc. No. D6841–A, roof rock, maceration 644–A, slide 3, coordinates 102.5×6.0, negative 5231. The specimen has a maximum diameter of 40 microns.

5. *Laevigatosporites subovalis* sp. nov. USGS Paleobotanical loc. No. D6841–A, roof rock, maceration 644–A, slide 4, coordinates 107.7×20.3, negative 5253. The specimen has a maximum diameter of 37.0 microns.

6. *Laevigatosporites clendeningii* sp. nov. USGS Paleobotanical loc. No. D6841–D, coal, maceration 644–D, slide 6, coordinates 121.4×11.9, negative 5235. The specimen has a maximum diameter of 102.5 microns.

7. *Leiotriletes adnatus* (Kosanke) Potonié and Kremp, USGS Paleobotanical loc. No. D6838–C, shale, maceration 502–C, slide 4, coordinates 116.6×8.9, negative 5192. The specimen has a maximum diameter of 40 microns.

8. *Leiotriletes* sp. USGS Paleobotanical loc. No. D6838–C, shale, maceration 502–C, slide 4, coordinates 116.7×18.8, negative 5180. The specimen has a maximum diameter of 45 microns.

9. *Microreticulatisporites sulcatus* (Wilson and Kosanke) Smith and Butterworth, USGS Paleobotanical loc. No. D6798–A, seat rock, maceration 565–A, slide 1, coordinates 97.5×14.5, negative 5248. The specimen has a maximum diameter of 41.4 microns.

10. *Reinschospora magnifica* Kosanke, USGS Paleobotanical loc. No. D6842–D, shale, maceration 852–D, slide 2, coordinates 117.1×14.3, negative 5204. The specimen has a maximum diameter of 58 microns.

11. *Reinschospora triangularis* Kosanke, USGS Paleobotanical loc. No. D6842–D, shale, maceration 852–D, single grain, coordinates 105.1×12.2, negative 5158. The specimen has a maximum diameter of 63 microns.

12. *Reticulatisporites* cf. *R. reticulocingulum* (Loose) Ravn, USGS Paleobotanical loc. No. D6842–D, shale, maceration 852–D, slide 6, coordinates 113.7×23.2, negative 5221. The specimen has a maximum diameter of 71.2 microns.

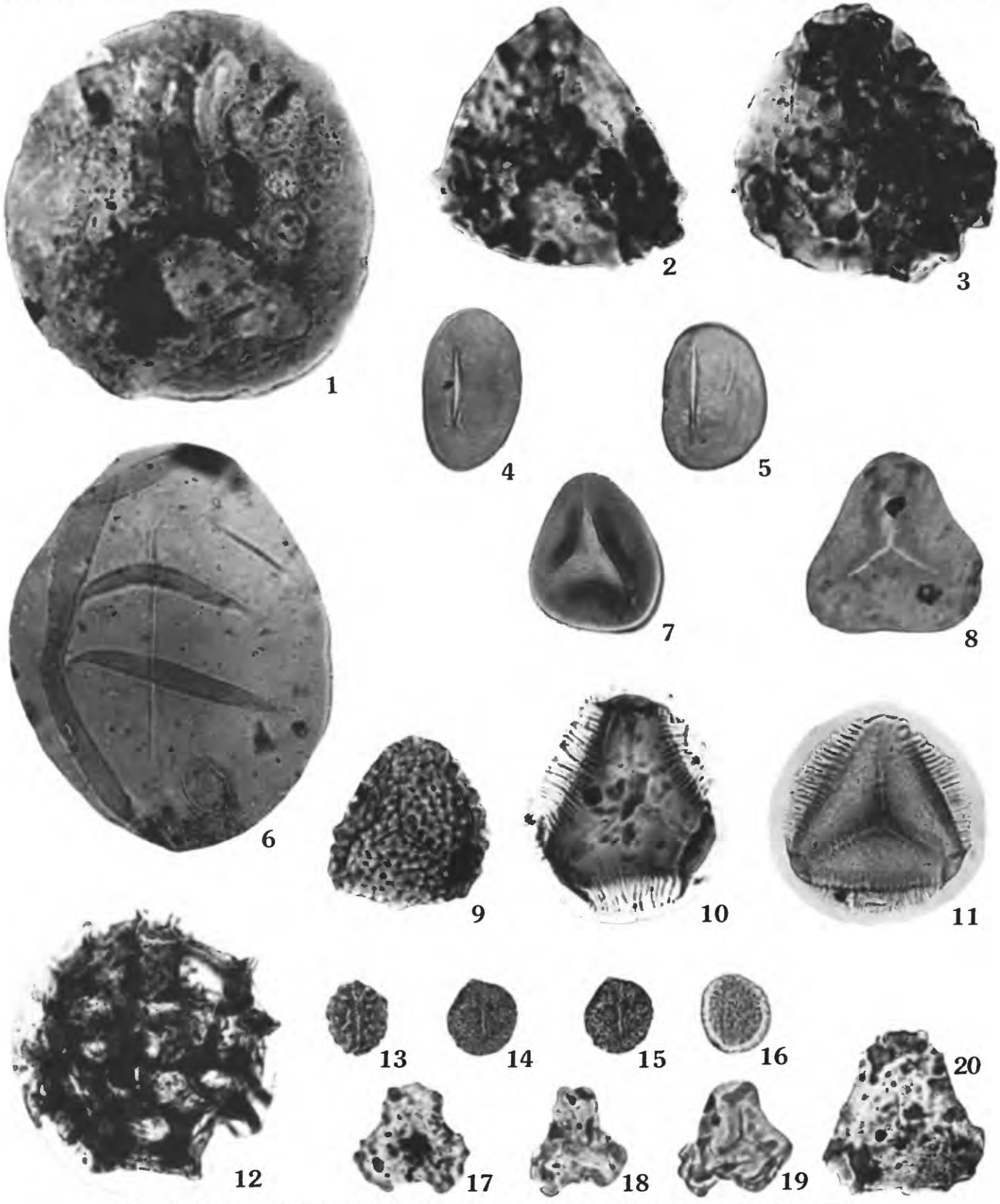
13. *Thymospora thiessenii* (Kosanke) Wilson and Venkatachala, USGS Paleobotanical loc. No. D6842–D, seat rock, maceration 852–D, slide 3, coordinates 110.2×16.5, negative 5342. The specimen has a maximum diameter of 20 microns.

14–15. *Thymospora parva* sp. nov., USGS Paleobotanical loc. No. D6842–A, roof rock, maceration 644–A. Figure 13, slide 4, coordinates 114.0×5.5, negative 5232. The specimen has a maximum diameter of 19.3 microns. Figure 15, same as figure 14, but different focus, negative 5262.

16. *Thymospora* sp. 1, USGS Paleobotanical loc. No. D6797–C, seat rock, maceration 538–C, slide 1, coordinates 117.8×2.2, negative 5330. The specimen has a maximum diameter of 20 microns.

17–19. *Triquitrites minutus* Alpern, USGS Paleobotanical loc. No. D6796–G, coal. Figure 17, maceration 472–G, slide 2, coordinates 115.9×8.7, negative 5293; maximum diameter is 26.2 microns. Figure 18, maceration 472–G, slide 1, coordinates 106.9×10.9, negative 5292; maximum diameter is 26.2 microns. Figure 19, maceration 472–G, slide 2, coordinates 112.0×22.9, negative 5294; maximum diameter is 27.5 microns.

20. *Triquitrites* cf. *T. sculptilis* (Balme) Smith and Butterworth, USGS Paleobotanical loc. No. D6795–B, seat rock, maceration 462–B, slide 2, coordinates 109.1×17.0, negative 5279. The specimen has a maximum diameter of 38 microns.



GRAVISPORITES, GILLESPIEISPORITES, LAEVIGATOSPORITES, LEIOTRILETES, MICRORETICULATISPORITES, REINSCHOSPORA, RETICULATISPORITES, THYMOSPORA, AND *TRIQUITRITES*

PLATE 3

FIGURES 1–2. *Tuberculatosporites robustus* (Kosanke) Peppers, USGS Paleobotanical loc. No. D6841–F and D6841–B. Figure 1, D6841–F, seat rock, maceration 644–F, slide 1, coordinates 117.6 × 15.6, negative 5273; maximum diameter is 125.6 microns. Figure 2, D6841–B, seat rock, maceration 644–B, slide 1, coordinates 103.0×7.9, negative 5233; maximum diameter is 120.9 microns.

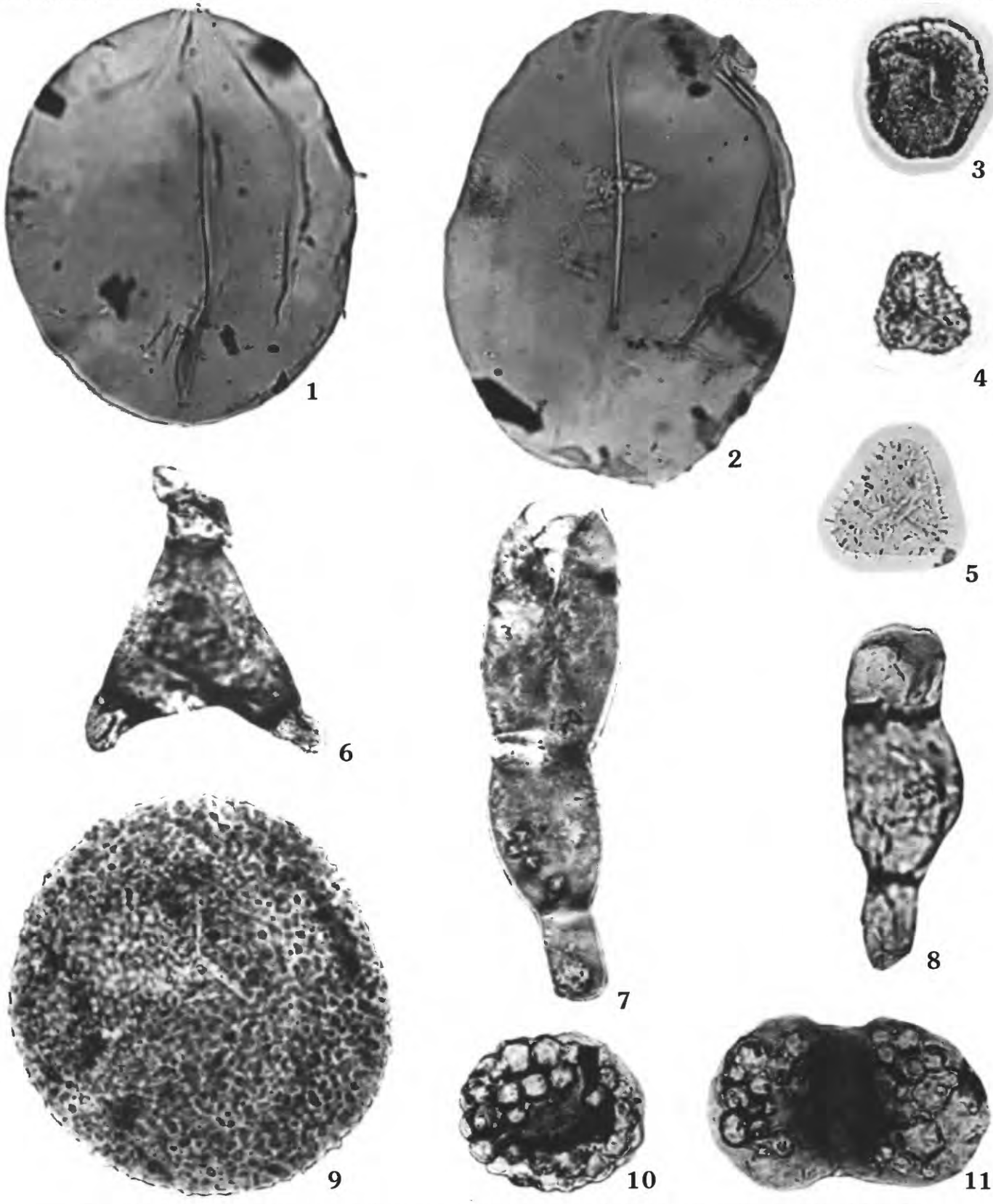
3–5. These specimens are distinctive but extremely rare in occurrence. For the present they are unassigned. Figure 3, USGS Paleobotanical loc. No. D6796–D, seat rock, maceration 472–D, slide 5, coordinates 117.5×2.8, negative 5209; maximum diameter is 30 microns. Figure 4, USGS Paleobotanical loc. No. D6839–E, shale, maceration 504–E, slide 1, coordinates 115.8×13.3, negative 5191; maximum diameter is 25.0 microns. Figure 5, USGS Paleobotanical loc. No. D6842–D, shale, maceration 852–D, slide 3, coordinates 108.4×11.2, negative 5209; maximum diameter is 43.7 microns.

6. *Trihyphaecites triangularus* Peppers, USGS Paleobotanical loc. No. D6842–A, coal, maceration 852–A, slide 7, coordinates 106.2×3.3, negative 5228. The specimen has a maximum diameter of 77.5 microns.

7–8. Illustrations of fungal septate hyphae. Figure 7, USGS Paleobotanical loc. No. D6842–C, coal, maceration 852–C, slide 5, coordinates 124.1×5.2, negative 5212; maximum diameter is 148.7 microns. Figure 8, USGS Paleobotanical loc. No. D6798–E, seat rock, maceration 565–E, slide 4, coordinates 114.4×18.1, negative 5250; maximum diameter is 81.8 microns.

9. *Verrucosisporites microtuberosus* (Loose) Smith and Butterworth, USGS Paleobotanical loc. No. D6842–A, coal, maceration 852–A, slide 7, coordinates 106.2×3.3, negative 5227. The specimen has a maximum diameter of 97.5 microns.

10–11. Poorly preserved monosaccate and bisaccate palynomorphs with extreme degradation of the bladders. Pyrite and quartz occur in abundance in a number of the noncoal and coal samples of the Conemaugh Formation. Figure 10, USGS Paleobotanical loc. No. D6842, shale, maceration 852–B, slide 7, coordinates 119.4×7.3, negative 5283; maximum diameter is 46 microns. Figure 11, USGS Paleobotanical loc. No. D6798–E, seat rock, maceration 565–E, slide 4, coordinates 115.6×9.1, negative 5251; maximum diameter is 68.1 microns.



TUBERCULATOSPORITES, UNASSIGNED, *TRIHYPHAECITES*, FUNGAL SEPTATE HYPHAE, *VERRUCOSISPORITES*, AND DEGRADATION OF MONOSACCATE AND BISACCATE PALYNOMORPHS

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