COMMONWEALTH OF VIRGINIA
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COAL BEDS, COAL ZONES, AND KEY STRATIGRAPHIC NAMES IN THE PENNSYLVANIAN UNITS OF SOUTHWESTERN VIRGINIA

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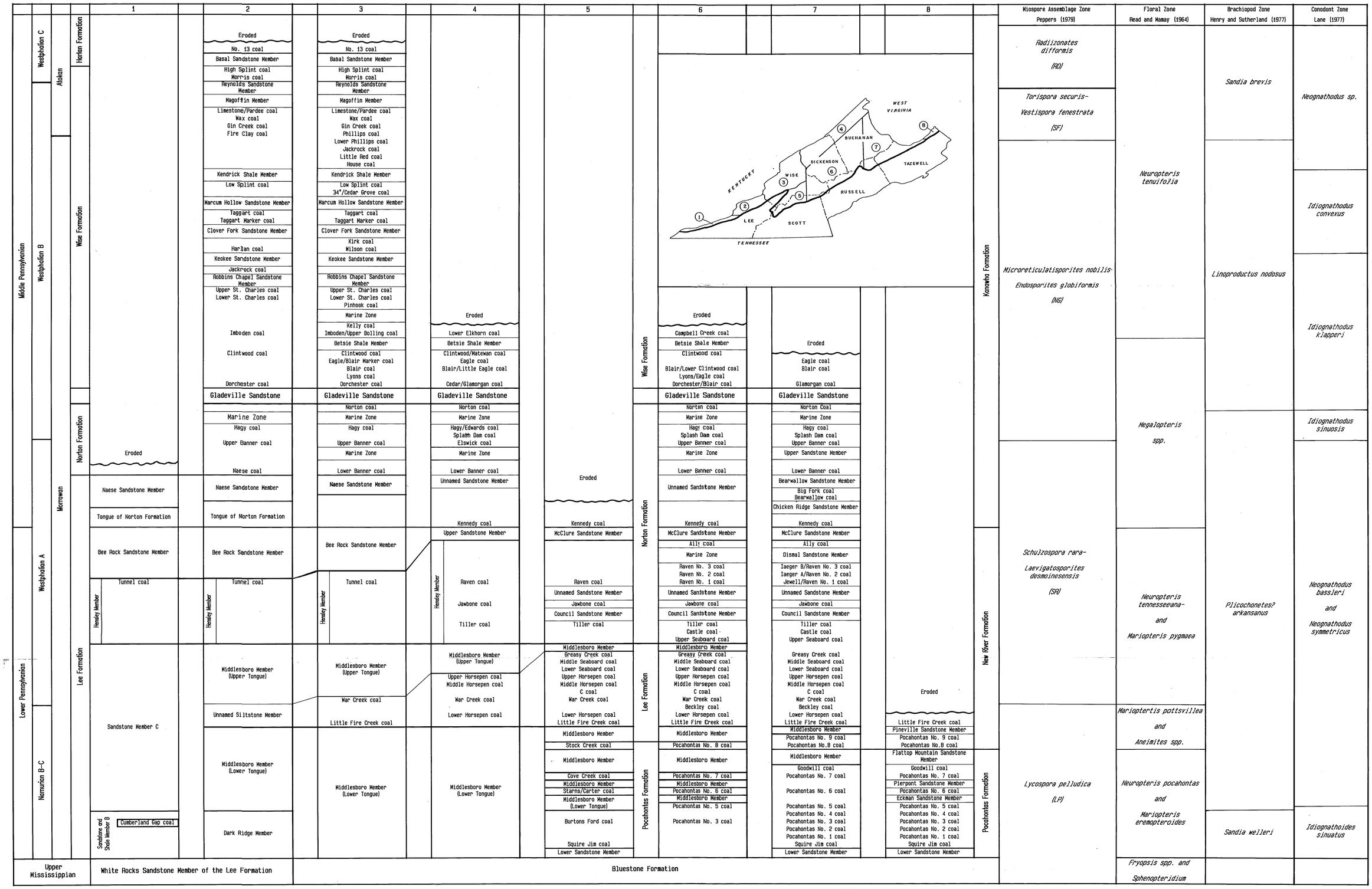

INTRODUCTION

Pennsylvanian strata underlie approximately 2100 square miles in southwestern Virginia and underlie all or parts of Lee, Wise, Scott, Dickenson, Russell, Buchanan, and Tazewell Counties (Inset map above). Pennsylvanian strata are as much as 5000 feet thick in western Wise County; but in most localities erosion has removed a considerable amount of rock and the strata only ranges from 2000 to 3500 feet in thickness. The region is divided into eight areas, based on state and county boundaries, and geologic and topographic features. The correlation chart of Pennsylvanian rocks of Virginia was prepared from published and unpublished reports. Eight columns are used in the chart and are arranged from southwest to northeast (left to right on the chart) across southwest Virginia. Vertical dimensions do not reflect either the actual thickness of units or relative time spans involved in their deposition.

CHRONOSTRATIGRAPHIC UNITS

Pennsylvanian rocks in the Appalachian basin have been traditionally divided into a lower, a middle, and an upper series. These series boundaries were formalized by Englund (1979). In Virginia only lower and middle Pennsylvanian rocks are present.

Based on invertebrate fossil data, Pennsylvanian rocks of southwestern Virginia are equivalent to the Morrowan and Atokan Series. Collections from "marine" zones above the Hagy coal, above the Clintwood coal, and in the Kendrick Shale (Jillson, 1919) contain the Morrowan fauna. The Magoffin Member of the WiseFormation contains an Atokan fauna (Morse, 1931). The boundary between the Morrowan and Atokan is tentatively placed at the base of the Phillips (Fire Clay) coal.

Gillespie and Pfefferkorn (1979) compared the plant megafossils of the Pennsylvanian System stratotype in southern West Virginia with the European sequence. From this comparison they assigned the Pocahontas Formation and that part of the New River Formation below the Beckley coal to the Namurian B and C intervals, respectively. They placed the Westphalian A interval from the base of the Beckley coal to just above the Sewell coal (Lower Seaboard coal). The Westphalian B interval was placed from the base of the Lower Seaboard upward to the base of the Winifrede (Morris) coal. Above the Winifrede coal the strata are assigned to the Westphalian C interval.

LITHOSTRATIGRAPHIC UNITS

Stratigraphic studies (Miller, 1969, Miller, 1974, and Nolde, 1994) and geologic mapping during the past 60 years have resulted in many changes in the nomenclature of Pennsylvanian strata. Earlier correlation tables (Moore and others, 1944; Brown and others, 1952) are no longer applicable because they were economically inspired and were oriented to the development of abundant and thick coal beds. A brief history of the development of Pennsylvanian nomenclature in Virginia is presented in Nolde (1994).

Coal beds and sandstone units are commonly discontinuous and seldom can be mapped or identified. The Dorchester, Blair, Clintwood, Taggart, Phillips, and Pardee coals typically form coal zones. The Clintwood and Phillips, in particular, are well represented as coal zones with as many as five splits. The partings between splits are as much as 40 feet thick and typically are composed of shale or siltstone. In general, coal bed and/or coal zone names presented in this chart are adopted from county reports (Eby, 1923; Giles, 1921, 1925; Harnsberger, 1919; Hinds, 1918; and Wentworth, 1922), the Geologic Quadrangle (GQ) Map series of the U. S. Geological Survey, the Bulletin and Publication series of the Virginia Division of Mineral Resources and other published sources.

POCAHONTAS FORMATION

The Pocahontas Formation was named by Campbell (1896) and defined as lying on top of the red shales of the Bluestone Formation and traceable upward to the top of the Pocahontas No. 3 coal bed. Later workers not only included the Pocahontas Nos. 1 to 3 coals but also Pocahontas Nos. 4 through 7 as well as an uppermost sandstone member (the Flattop Mountain Sandstone) in the Pocahontas Formation (White, 1908; Hennen and Gawthrop, 1915).

Characteristically, the Pocahontas Formation is dominantly composed of gray shale and siltstone, however sandstones that may have a maximum individual thickness of about 100 feet are prominent locally. These sandstones are typically light gray, fine to mediumgrained, micaceous, and feldspathic. The formation is characterized by wide distribution of coals and underclay. Many of the coals are relatively thick and commonly range from 2 to 6 feet. The formation is as much as 750 feet thick but thins both to the northwest and southwest where it was eroded away before deposition of overlying sediments which now make up the basal beds of the Lee Formation.

A sandstone which occurs at the base of the formation is informally called the "lower sandstone member." The top of the formation throughout areas 5, 7 and 8 are marked by the presence of the Flattop Mountain Sandstone Member which lies above the Pocahontas No. 7 coal bed.

NEW RIVER FORMATION

Fontaine (1874) named the New River Formation, for exposures along the New River in Fayette and Raleigh Counties, West Virginia. Read and Mamay (1964) redefined the New River Formation as a unit from the top of the Flattop Mountain Sandstone at the top of the Pocahontas Formation to the top of the Nuttall Sandstone Member. The use of the New River terminology is restricted to eastern Buchanan County, northeastern Russell County, and all of the coal-bearing portion of Tazewell County, where the quartzarenite members of the Lee Formation are indistinguishable.

The New River Formation is about 1600 feet thick. Like the Pocahontas Formation, the New River is characterized by thedominance of shale, siltstone, and sandstone. Three mappable sandstone members occur throughout eastern Buchanan and Tazewell Counties. They are from oldest to youngest: the Pineville (Hennen and Gawthrop, 1915), the Council (Miller and Meissner, 1977), and an unnamed sandstone below the Raven coal. The sandstones of this formation are considered to be transitional from the relatively pure quartz sandstones of the Lee Formation to argillaceous and micaceous sandstones of younger Pennsylvanian formations. In Virginia coals of the New River Formation are generally thicker and much more widely traceable than the coals of the underlying Pocahontas. However, the coals are rarely more than 24 inches thick and have much less continuity than younger coals.

In general, "marine" zones are rare in this formation. A relatively thin, discontinuous, calcareous, fossiliferous marine shale overlies the Pocahontas No. 8 coal in eastern Buchanan and Tazewell Counties (Englund, 1974).

KANAWHA FORMATION

The Kanawha Formation, named for exposures along the Kanawha River, between Gauley Bridge and Charleston, West Virginia is defined as a unit from the top of the Nuttall Sandstone Member to the top of the Kanawha black flint (Campbell and Mendenhall, 1896). The Kanawha Formation ranges from 500 to 700 feet thick. It is dominantly gray shale, but sandstones are prominent locally and range in thicknesses from less than one foot to as much as 130 feet. Sandstone bodies are generally linear in their maximum development and are interpreted to be filled fluvial channels. Five traceable sandstone members occur throughout eastern Buchanan and Tazewell Counties. They are from oldest to youngest: the Dismal (Englund, 1981), McClure (Eby, 1923), Chicken Ridge (Englund, 1981), Bearwallow (Englund, 1981), and an unnamed sandstone. The formation is characterized by a wide distribution of individual coals. Many of the coals in this formation are relatively thick and commonly range from 2 to 4 feet thick.

LEE FORMATION

Campbell (1893) named the Lee Formation for exposures along the northwest boundary of Lee County, Virginia and defined it as "three massive sandstones or conglomerates separated by intervals of siltstone and shale." In the type area, the Lee is divided into eight members (Englund, 1964): the Pinnacle Overlook, Chadwell, White Rocks Sandstone, Dark Ridge, Middlesboro, Hensley, Bee Rock Sandstone, and the Naese Sandstone. The lower three members, Pinnacle Overlook, Chadwell, and White Rocks Sandstone, which only occur in Lee County, are assigned to the Upper Mississippian Series, because they intertongue with the Upper Mississippian Pennington (Bluestone and Hinton) Formation. The Dark Ridge Member is considered to be Mississippian to Pennsylvanian in age. Englund and Delaney (1966) and Nolde (1994) have correlated the Dark Ridge Member with the Pocahontas Formation which contains *Neuropteris pocahontas*.

Throughout the Appalachian Plateaus area, the Lee Formation consists of the Middlesboro, Hensley, Bee Rock Sandstone, and the Naese Sandstone Members. Miller (1974) referred to the threemassive sandstone members recognized by Campbell as the lower, middle, and upper quartzarenites. Because the Lee Formation is recognized as a lithostratigraphic unit with lower and upper contacts defined by quartzose sandstones, the bounding contacts are not always defined by the same member. The lower and middle quartzarenites are within the Middlesboro Member and the upper quartzarenite corresponds to the Bee Rock Sandstone and the Naese Sandstone Members. In areas 1 and 2 the top of the Lee is defined by the top of the Naese Sandstone Member, in areas 3 and 4 the Bee Rock Sandstone Member, and in areas 5, 6, and part of 7 the top of the various quartzarenites of the Middlesboro Member.

NORTON FORMATION

The Norton Formation was defined by Campbell (1893) as a unit from the top of the Lee Formation upward to the bottom of the Gladeville Sandstone. In the western part of the area, the top of the Naese Sandstone Member of the Lee Formation is defined as the lower boundary, in the central part of the area the top of the Bee Rock Sandstone Member, and in the eastern part the top of the quartzarenites of the Middlesboro Member of the Lee Formation. To further complicate the picture, in Buchanan County the Lee and Norton Formations intertongue. In addition, the Bee Rock Sandstone Member of the Lee Formation is traceable laterally into the McClure Sandstone Member of the Norton Formation. The Norton Formation is a heterogeneous sequence of interlayered dark- to medium-gray siltstone and shale, and lesser amounts of sandstone. Non-resistant interlayered siltstone and shale form the lower 200 to 300 feet of the formation, above which are characteristically resistant, medium gray, fine- to medium-grained, micaceous and feldspathic sandstone. The formation contains the principal coal beds that have been mined extensively in Buchanan and Tazewell Counties.

Four "marine or restricted marine" zones have been recognized in the Norton Formation. These zones occur, 1) above the Hagy coal (formerly called the Eagle Shale by White, 1891), 2) above the Splash Dam coal (possibly the Oceana Shale of Hennen and Gawthrop, 1915 or Dorothy Shale of Krebs and Teets, 1916), 3) above the Lower Banner coal, and 4) below the Ally coal. These zones are principally dark-gray shales that range from 5 to 15 feet thick and commonly contain ellipsoidal limestone lenses. The fossils that occur in the shales typically are linguloid and orbiculoid brachiopods.

GLADEVILLE SANDSTONE

Campbell (1893) named the Gladeville Sandstone, for the Town of Gladeville (now Wise), Wise County, and defined it as a "massive sandstone or conglomerate" that occupies a part of the stratigraphic section from the top of the Norton Formation to the base of the Dorchester coal. The thickness of the Gladeville was described as being about 75 to 120 feet. Throughout the area the Gladeville has been misidentified as a sandstone lower in the section. Miller (1969) and Whitlock (1987) restrict the Gladeville to the sandstone which lies below the Dorchester coal, the basal unit of the Wise Formation. The Gladeville Sandstone ranges in thickness from 30 to 50 feet and is medium gray to white, fine to medium grained, massive bedded, and quartzose to feldspathic sandstone that contains mica, heavy minerals, and carbonaceous matter. The sandstone is generally trough cross bedded but locally contains planar beds.

WISE FORMATION

The Wise Formation was named by Campbell (1893) for exposures in Wise County and defined as a unit from the top of the Gladeville Sandstone upward to the base of the Harlan Formation. The Wise Formation ranges from less than one foot to 2400 feet in thickness. Characteristically, the formation is dominated by siltstone and shale; locally thick sandstone beds are common. The siltstones are light to medium gray and contain moderate-red-ironstone nodules and lenses. Sandstones are light to medium gray, fine to medium grained, and cross bedded. The sandstones may have either silica or calcareous cement. The formation includes coal beds that have been extensively mined in Dickenson and Wise Counties. Although shales are relatively minor in the Wise Formation, several shale units of appreciable continuity occur. Shale beds are dark gray to black and contain fossil plants and occasional freshwater and brackish water or marine invertebrate fossils. Three "marine" shale zones are widespread throughout the region. These are the Betsie Shale Member, formerly Cannelton Shale of White (1885), theKendrick Shale (Jillson, 1919), and the Magoffin Member (Outerbridge, 1976), previously known as the Magoffin beds of Morse (1931). These zones are composed of dark-gray to black, laminated shale, 10 to 20 feet thick, and locally contain ellipsoidal, silty calcareous lenses with cone-in-cone structures and brackish or marine invertebrate fossils. The Magoffin Member contains a fossil-hash limestone bed as much as two feet in thickness. Other localized zones containing brackish or marine invertebrate fossils occur above the Kelly coal, above the Marcum Hollow Sandstone Member, and above the Gin Creek coal.

HARLAN FORMATION

The Harlan Formation was named for exposures in Harlan County, Kentucky and was defined as occupying a stratigraphic interval from the bottom of a basal cliff-forming sandstone upward to the erosional top of Big Black Mountain (Campbell, 1893). As the basal sandstone does not occur continuously throughout the area, as a result much confusion exists about the location of the base of the Harlan Formation. Miller (1969) redefined the base of the Harlan Formation as being the top of the High Splint coal at the top of the Wise Formation. The Harlan Formation has a maximum preserved thickness of about 600 feet. It consists predominantly of light- to medium-gray, fine- to medium-grained sandstone with some interbedded medium-gray siltstone, shale, and coal.

BIOSTRATIGRAPHIC UNITS

Read and Mamay (1964) were the first to utilize fossil floras to develop biostratigraphic zones in the Pennsylvanian System and recognized nine distinct and readily recognizable zones in the system. Pennsylvanian rocks in Virginia contain characters of Read and Mamay's zones 4 through 8.

Floral zone 4 of Read and Mamay (1964), distinguished by *Neuropteris pocahontas* D. White and *Mariopteris eremopteroides* D. White, first appears in the upper member of the Bluestone Formation and in the basal part of the contemporaneously-deposited lower sandstone member of the Pocahontas Formation. The base of this lowermost sandstone unit of the Pocahontas has been established as the boundary between the Mississippian and Pennsylvanian Systems at the stratotype by the U.S. Geological Survey (Englund and others, 1985). This horizon coincides with the lowest known occurrence of Floral zone 4, and, based on the macroflora, also coincides closely with the Namurian "A" and Namurian "B" boundary in western Europe.

Floral zone 5 of Read and Mamay (1964), distinguished by *Mariopteris pottsvillea* and of common occurrence of *Aneimites* spp., first appears near the Pocahontas No. 8 coal bed and continues upward to the base of the Beckley coal bed. The Namurian "B" and "C" boundary in Virginia are inseparable in Virginia on megafloras.

Floral zone 6 of Read and Mamay (1964), distinguished by *Neuropteris tennesseeana*, *Mariopteris pygmaea*, *Ovopteris communis*, *Alliopteris inaequilateralis*, and *Alethopteris decurrens*, appears near the bottom of the Beckley coal bed and continues upward to the base of the Kennedy coal bed. The boundary between the Namurian"C" and Westphalian "A" lies near the top of the Beckley coal bed. Westphalian "A" extends upward to the Splash Dam coal bed.

Floral zone 7 of Read and Mamay (1964), distinguished by *Megalopteris* spp. appears near the base of the Kanawha Formation (Kennedy or Douglas coal bed) and continues upward to the base of the Eagle (Lyons) coal bed. The interval correlates with the Westphalian "B" horizon of western Europe.

Floral zone 8 of Read and Mamay (1964), distinguished by *Neuropteris tenuifolia*, is found near the base of the Imboden coal bed and can be traced upward to the eroded top of the Harlan Formation. The boundary between the Westphalian "B" and "C" occurs at base of the Morris coal bed. The Remaining Wise and Harlan Formations are assigned to the Westphalian "C" horizon.

Spore assemblages from the Pennsylvanian stratotype (Kosanke, 1984, 1988) and a Jefferson National Forest core hole (Eble and Gillespie, 1989) show that *Lycospora* dominates the Pocahontas and Lee Formations. The occurrence and disappearance of several biostratigraphically important miospores such as *Schulzospora rara* and *Laevigatosporites* spp. help establish correlations of Pennsylvanian coal beds of southwestern Virginia with the coal beds of the Illinois and Black Warrior basins. Species of *Schulzospora*, especially *S. rara*, can be found in every coal sample from the Pocahontas and Lee Formation (Eble and Gillespie, 1989). In eastern Kentucky, *Schulzospora* ranges up to the Splitseam coal bed (Kosanke, 1982) which is correlative with the Splash Dam coal bed in Virginia.

Peppers (1979) defined 11 miospore assemblage zones in the Pennsylvanian System in the Illinois basin and correlated them with the upper Carboniferous of Europe. Of the 11 zones, five are recognizable in Pennsylvanian strata in Virginia. These spore assemblages are: *Lycospora pelludica* (LP) Zone, *Schulzospora rara–Laevigatosporites desmoinesensis* (SR) Zone, *Microreticulatisporites nobilis–Endosporites globiformis* (NG) Zone, *Torispora securis–Vestisporafenestrata* (SF) Zone, and *Radiizonates difformis* (RD) Zone.

Henry and Sutherland (1977) presented the scheme for subdivision of Morrowan and Atokan Series rocks based on brachiopods. The Morrowan Series is divided into three brachiopod range and assemblage zones: *Sandia wellerii*, *Plicochonetes(?) arkansanus*, and *Linoproductus nodosus*. These three zones are also recognized in Virginia. The Atokan Series equivalents in Virginia are assigned to the *Sandia brevis* Zone.

From work in the mid-continent area Lane and Straka (1974) and Lane (1977) have proposed a type Morrowan conodont zonation. They divided the Morrowan Series into eight conodont zones. Of these eight zones that are present in the mid-continent, seven are recognized in equivalent rocks in Virginia. The zones recognized in Virginia are *Idiognathoides sinuatus*, *Neognathodus symmetricus-Neognathodus basserli* (these two zones are inseparable in Virginia), *Idiognathodus sinuosus*, *Idiognathodus klapperi*, *Idiognathodus convexus*, and *Neognathodus* n. sp. The *Neognathodus* n. sp. is traceable into the lower part of the Atokan Series.

REFERENCES

Brown, A., Berryhill, H. L., Taylor, D. A., and Trumbull, J. V. A., 1952, Coal Resources of Virginia: U.S. Geological Survey Circular 171, 57 p.

Campbell, M. R., 1893, Geology of the Big Stone Gap coal field of Virginia and Kentucky: U.S. Geological Survey Bulletin 111, 106 p.

Campbell, M. R., 1896, Description of the Pocahontas sheet, Virginia-West Virginia: U.S. Geological Survey, Atlas Folio 26.

Campbell, M. R., and Mendenhall, W. C., 1896, Geologic section along the New and Kanawha Rivers in West Virginia: U.S. Geological Survey Annual Report 17, pt. 2, p. 473-511.

Eble, C. F., and Gillespie, W. H., 1989, Palynology of selected Pennsylvanian coal beds from the central and southern Appalachian basin: Correlation and stratigraphic implications, *in* Englund, K. J., editor, Characteristics of the mid-Carboniferous boundary and associated coal-bearing rocks in the central and southern Appalachian basin: International Geological Conference Field Trip T352B, p. 61-66.

Eby, J. B., 1923, Geology and mineral resources of Wise County and the coal-bearing portion of Scott County, Virginia: Virginia Geological Survey Bulletin 24, 617 p.

Englund, K. J., 1964, Stratigraphy of the Lee Formation in the Cumberland Mountains of southeastern Kentucky: U.S. Geological Survey Professional Paper 501-B, p. B30-B38.

Englund, K. J., 1974, Sandstone distribution patterns in the Pocahontas Formation of southwest Virginia and southern West Virginia, *in* Briggs, G., editor, Carboniferous of the southeastern United States: Geological Society of America Special Paper 148, p. 31-45.

Englund, K. J., 1979, The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States-Virginia: U.S. Geological Survey Professional Paper 1110-C, 21 p.

Englund, K. J., 1981, Geologic map of the Jewell Ridge quadrangle, Buchanan and Tazewell Counties, Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1550, Scale 1:24,000.

Englund, K. J., and Delaney, A. O., 1966, Intertonguing relations of the Lee Formation in southwestern Virginia, *in* Geological Survey Research: U.S. Geological Survey Professional Paper 550-D, p. D47-D52.

Englund, K. J., Henry, T. W., Gillespie, W. H., Pfefferkorn, H. W., and Gordon, M., Jr., 1985, Boundary stratotype for the base of the Pennsylvanian System, east-central Appalachian basin, U.S.A.: Dixième Congres International de Stratigraphie et de Geologie du Carbonifere, Compte Rendu, v. 4, p. 371-382.

Fontaine, W. M., 1874, The "Great Conglomerate" on New River: American Journal of Science, 3d ser., v. 7, p. 459-465.

Giles, A. W., 1921, The geology and mineral resources of Dickenson County, Virginia: Virginia Geological Survey Bulletin 21, 224 p.

Giles, A. W., 1925, The geology and coal resources of the coal-bearing portion of Lee County, Virginia: Virginia Geological Survey Bulletin 26, 216 p.

Gillespie, W. H., and Pfefferkorn, H. W., 1979, Distribution of commonly occurring plant megafossils in the proposed Pennsylvanian System stratotype, *in* Englund, K.J., Arndt, H.H., and Henry, T.W., editors, Proposed Pennsylvanian Stratotype, Virginia and West Virginia: American Geological Institute Guidebook No. 1, p. 87-96.

Harnsberger, T. K., 1919, The geology and coal resources of the coal-bearing portion of Tazewell County, Virginia: Virginia Geological Survey Bulletin 19, 195 p.

Hennen, R. V., and Gawthrop, R. M., 1915, Wyoming and McDowell Counties: West Virginia Geological Survey County Report, 783 p.

Henry, T.W., and Sutherland, O.K., 1977, Brachiopod biostratigraphy of Morrowan Series (Pennsylvanian) in northwestern Arkansas and northeastern Oklahoma, *in* Sutherland, P. K. and Manger, W. L., editors, Mississippian-Pennsylvanian boundary in northeastern Oklahoma and northwestern Arkansas: Oklahoma Geological Survey Guidebook 18, p. 107-116.

Hinds, H. H., 1918, The geology and coal resources of Buchanan County, Virginia: Virginia Geological Survey Bulletin 18, 278 p.

Jillson, W. R., 1919, The Kendrick Shale-a new calcareous fossil horizon in the coal measures of eastern Kentucky, *in* Mineral and Forest Resources of Kentucky: Department of Geology and Forestry, ser. 5, v. 1, n. 2, p. 96-104.

Kosanke, R. M., 1982, Mississippian-Pennsylvanian boundary in the United States based on palynomorphs, *in* Ramsbottom, W. H. C. and others, (editors), Biostratigraphic data for a mid-Carboniferous boundary: Proceedings Subcommission on Carboniferous Stratigraphy, Leeds, p. 27-35.

Kosanke, R. M., 1984, Palynology of selected coal beds in the proposed Pennsylvanian System stratotype in West Virginia: U.S. Geological Survey Professional Paper 839, 44 p.

Kosanke, R. M., 1988, Palynological studies of Lower Pennsylvanian coal beds and adjacent strata of the proposed Pennsylvanian System stratotype in Virginia and West Virginia: U.S. Geological Survey Professional Paper 1479, 21 p.

Krebs, C. E., and Teets, D. D., Jr., 1916, Raleigh County and the western portions of Mercer and Summers Counties: West Virginia Geological Survey County Report, 778 p.

Lane, H. R., 1977, Morrowan. (Early Pennsylvanian) conodonts of northwestern Arkansas and northeastern Oklahoma, *in* Sutherland, P.K. and Manger, W.L., editors, Mississippian-Pennsylvanian boundary in northeastern Oklahoma and northwestern Arkansas: Oklahoma Geological Survey Guidebook 18., p. 177-180.

Lane, H. R., and Straka, J., 1974, Late Mississippian and Early Pennsylvanian conodonts, Arkansas and Oklahoma: Geological Society of America Special Paper 152, 144 p.

Miller, M. S., 1974, Stratigraphy and coal beds of Upper Mississippian and Lower Pennsylvanian rocks of southwestern Virginia: Virginia Division of Mineral Resources Bulletin 84, 211 p.

Miller, R. L., 1969, Pennsylvanian formations of southwest Virginia: U.S. Geological Survey Bulletin 1280, 62 p.

Miller, R. L., and Meissner, C. R., 1977, Geologic map of the Big A Mountain quadrangle, Buchanan and Russell Counties, Virginia: U.S. Geological Survey, Geologic Quadrangle Map GQ-1350, scale 1:24000.

Moore, R. C., and others, 1944, Correlation of Pennsylvanian formations of North America: Geological Society of America Bulletin, v. 55, p. 657-706.

Morse, W. C., 1931, The Pennsylvanian invertebrate fauna of Kentucky, *in* Jillson, W.R., The paleontology of Kentucky: Kentucky Geological Survey, p. 295-349.

Nolde, J. E., 1994, Devonian to Pennsylvanian Stratigraphy and coal beds of the Appalachian Plateaus Province, *in* Geology and Mineral Resources of the Southwest Virginia Coalfield: Virginia Division of Mineral Resources Publication 131, p. 1-85.

Outerbridge, W. F., 1976, The Magoffin Member of the Breathitt Formation, *in* Cobee, G.V., and Wright, W. B., (editors), Changes in Stratigraphic Nomenclature-1975: U.S. Geological Survey Bulletin 1422-A, p. A64.

Peppers, R. A., 1979, Comparison of miospore assemblages in the Pennsylvanian System of the Illinois basin with those in the Upper Carboniferous of western Europe: Neuvieme Congres International de Stratigraphie et de Geologie du Carbonifere, Compte Rendu, v. 2, p. 483-502.

Read, C. B., and Mamay, S. H., 1964, Upper Paleozoic floral zones and floral provinces of the United States: U.S. Geological Survey Professional Paper 454-K, 35 p.

Wentworth, C. K., 1922, The geology and coal resources of Russell County, Virginia: Virginia Geological Survey Bulletin 22, 179 p.

White, I. C., 1885, Nomenclature of Appalachian coal beds: The Virginias, v. 6, p. 7-16.

White, I. C., 1891, Stratigraphy of the bituminous coal fields of Pennsylvania, Ohio, and West Virginia: U.S. Geological Survey Bulletin 65, 212 p.

White, I. C., 1908, Supplementary coal report: West Virginia Geological Survey, v. 2-A, 720 p.

Whitlock, W. W., 1987, Recorrelation of the Gladeville Sandstone in Wise County, Virginia (abs.): Virginia Journal of Science, v. 38, n. 2, p. 132.

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