

Age of the Bedford Shale,
Berea Sandstone, and
Sunbury Shale in the
Appalachian and Michigan Basins,
Pennsylvania, Ohio, and Michigan

By WALLACE DE WITT, JR.

CONTRIBUTIONS TO STRATIGRAPHY

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III

AGE OF THE BEDFORD SHALE, BEREASANDSTONE, AND SUNBURY SHALE IN THE APPALACHIAN AND MICHIGAN BASINS, PENNSYLVANIA, OHIO, AND MICHIGAN

By WALLACE DE WITT, JR.

ABSTRACT

The suggestion by Sanford (1967, p. 994) that the Bedford Shale, Berea Sandstone, and Sunbury Shale of the Michigan basin are of Late Devonian age because these strata contain *Hymenozonotriletes lepidophytus* Kedo is invalid for these formations in the Appalachian basin, the area of their type localities. *Endosporites lacunosus* Winslow, a synonym of *Hymenozonotriletes lepidophytus* Kedo, occurs in upper Chautauqua (Upper Devonian) rocks through much of the Kinderhook (Lower Mississippian) strata in Ohio. The Sunbury Shale, the Sunbury Member of the Orangeville Shale in part of northern Ohio, contains a *Siphonodella* fauna which clearly demonstrates the Kinderhook age of the unit. The basal strata of the Bedford Shale contain *Spathognathodus anteposicornis* which suggests a very Late Devonian or very Early Mississippian age for this part of the Bedford. Except for the basal fossil zone, most of the Bedford Shale and the younger Berea Sandstone overlie the Murrysville sand, which along the Allegheny Front in central Pennsylvania contains an *Adiantites* flora of Early Mississippian (Kinderhook) age. The presence of *Adiantites* in the Murrysville sand indicates that most of the Bedford Shale and all the Berea Sandstone are of Early Mississippian age. Lithostratigraphic evidence suggests that the Berea Sandstone of Ohio may be a temporal equivalent of the basal Beckville Member of the Pocono Formation of the Anthracite region of Pennsylvania.

The clearly demonstrable Kinderhook age of the Sunbury, Berea, and most of the Bedford in the Appalachian basin strongly indicates a similar age for the same units in the Michigan basin.

PURPOSE

Sanford (1967, p. 994) reported *Hymenozonotriletes lepidophytus* Kedo in the Berea Sandstone and Sunbury Shale of the Michigan basin, and because of the presence of this spore he assigned a Late

Devonian age to these formations as well as to the subjacent Bedford Shale. Shifting the three formations from the Mississippian to the Devonian in the Michigan basin requires a similar change in age of these units in the Appalachian basin where the type localities of the three formations are located. Because a Late Devonian age is incompatible with much of the stratigraphic data for the Bedford, Berea, and Sunbury (Pepper and others, 1954, p. 13; Hass, 1947, p. 133), I have attempted to review and synthesize much of the data on the age of these strata that have become available since Pepper and his associates published their comprehensive work on the Bedford Shale and Berea Sandstone in 1954. The purpose of this review is to determine as closely as possible the age of the three formations in the Appalachian basin and to extrapolate these data into the Michigan basin.

ACKNOWLEDGMENTS

I wish to thank George V. Cohee, John W. Huddle, and James M. Schopf, who are of the U.S. Geological Survey, for reviewing this paper. Their helpful suggestions are gratefully acknowledged. I have relied heavily on J. M. Schopf for paleobotanical information and on J. W. Huddle for the ranges of specific conodonts.

AGE AND CORRELATION IN THE APPALACHIAN BASIN

In discussing palynologic data for the detailed stratigraphy of the Strunian (*Tn 1a*) of the Ardennes area, Strel (1966, p. 70) stated that *Endosporites lacunosus* Winslow was synonymous with *Hymenozonotriletes lepidophytus* Kedo. Winslow (1962, p. 45) found that in Ohio *Endosporites lacunosus* ranged from the base of the Cleveland Member of the Ohio Shale upward into the post-Sunbury part of the Orangeville Shale of the Cuyahoga Group (fig. 1). The spore is most abundant in the Bedford Shale and overlying Berea Sandstone and is much less abundant in collections from the strata above and below these two formations.

Conodont faunas in the Cleveland Member of the Ohio Shale show that it is of Late Devonian age (Hass, 1956, p. 23; Oliver and others, 1967, p. 1007) and probably correlates with strata in the *Spathognathodus costatus* zone (to VI) in the upper part of the Famennian (Oliver and others, 1967, p. 1035). The Sunbury Shale, the basal member of the Orangeville Shale in parts of northern Ohio, contains an abundant *Siphonodella* fauna of Early Mississippian (Kinderhook) age (fig. 2) and appears to correlate with strata in the upper part of *Tn 1b* and *Tn 2a* in the lower part of the Tournaisian (Mamet, 1967, p. 1003). These faunal data show that in the northwestern part

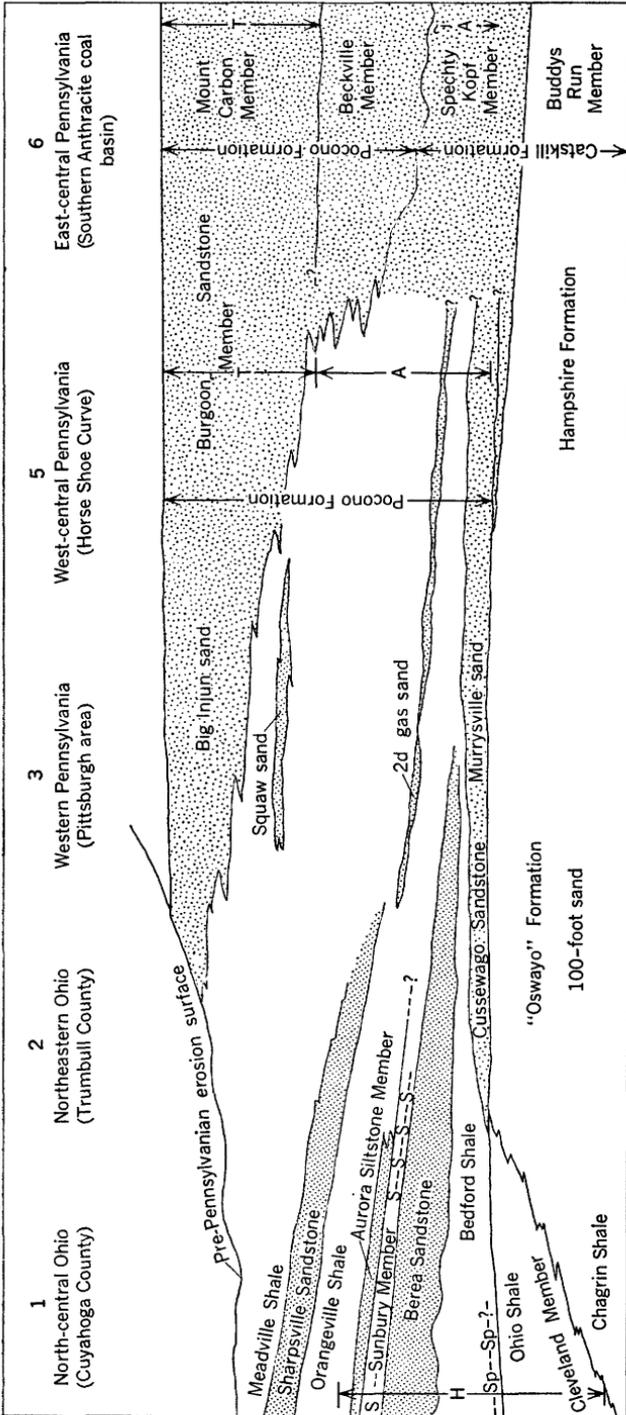


FIGURE 1.—Schematic stratigraphic section from northern Ohio to central Pennsylvania. A, range of *Adiantites* flora; H, range of *Hymenozonotrites lepidophytus* Kedo; S, range of *Siphonodeila*; Sp, range of *Spathognathodus anteposicornis* Scott; T, range of *Triphlopteria* flora. Numbers refer to localities shown in figure 3.

of the Appalachian basin *Hymenozonotriletes lepidophytus* Kedo spans the Devonian-Mississippian boundary; hence, the spore cannot be used to substantiate a Devonian age assignment for the Bedford, Berea, or Sunbury.

Mamet (1967) reviewed many of the problems associated with the placement of the Devonian-Carboniferous systemic boundary in the rocks of the Ardennes area of southern Belgium and adjacent north-east France, including the relation of the Famennian-Tournaisian Series boundary to the systemic boundary and the uncertainties surrounding the age assignment of the Etroeungt Limestone. Although intercontinental correlations are less certain than those in the United States, the faunal and floral data indicate that strata in the Ardennes area which correlate with the *Hymenozonotriletes lepidophytus*-bearing rocks of Ohio range from the upper part of the Famennian (to VI) of unquestioned Late Devonian age into the lower part of the Middle Tournaisian (*Tn 2a*), the lower part of the *Gattendorfa* zone of Early Carboniferous age.

In north-central Ohio (fig. 3) in the vicinity of Cleveland, Cuyahoga County, a zone in the basal few feet of the Bedford Shale contains invertebrate fossils which are similar to the fauna of the Louisiana Limestone of the Mississippi Valley. The conodont *Spathognathodus anteposicornis* is present in the basal fossil zone of the Bedford Shale (Oliver and others, 1967, p. 1035) and has been reported from the Louisiana Limestone. Collinson and others (1967, p. 962) assigned the Louisiana to the latest Devonian and suggested that the top of the limestone marks the Devonian-Mississippian boundary in parts of the Mississippi Valley area. Gutschick and Moreman, however (1967), reviewed much of the paleontologic data that has been used for determining the Devonian-Mississippian boundary adjacent to the craton in the central part of the United States and concluded that the base of the Louisiana Limestone should be the base of the Mississippian in the Mississippi Valley area. By correlation with the fauna in the Louisiana Limestone, the basal fossil zone of the Bedford Shale may be either very Late Devonian or very Early Mississippian. Also, according to J. W. Huddle (written commun., 1969), *Spathognathodus anteposicornis* occurs above *Siphonodella* in England in the Avonian, Lower Carboniferous (Rhodes and others, 1969, p. 222), and the species is probably not restricted to the latest Devonian conodont zone (upper *Spathognathodus costatus* zone).

Except for the basal fossil zone and a scattering of spores, the Bedford Shale is largely unfossiliferous in most of its extent in eastern Ohio, extreme northwestern Pennsylvania, and northeastern Kentucky. The overlying Berea Sandstone is similarly relatively unfossiliferous. A few fossils have been found in the Berea, but, in general,

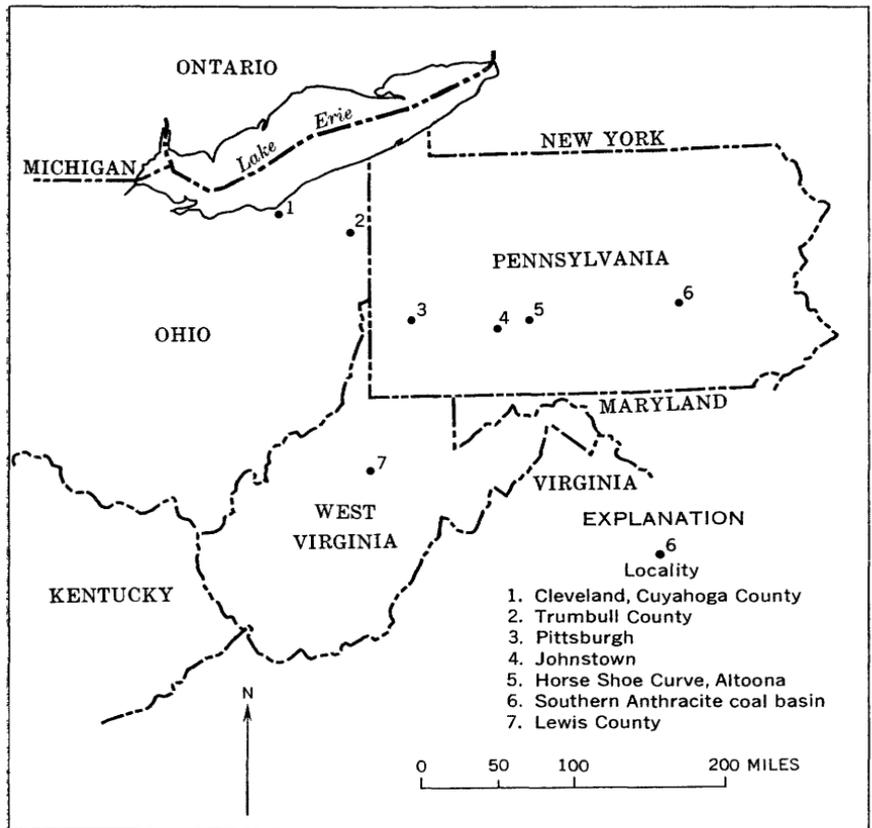


FIGURE 3.—Localities mentioned in this report.

they are long-ranging nondiagnostic forms or are too fragmentary for specific identification. In contrast, the overlying Sunbury Shale contains a conodont zone, characterized by several species of *Siphonodella*, in its basal beds throughout a large area in the western part of the Appalachian basin. The several species of *Siphonodella* which occur abundantly in the basal zone of the Sunbury permit correlation of the Sunbury with the Hannibal Shale and other *Siphonodella*-bearing units in the Lower Mississippian strata of the Mississippi Valley area (Hass, 1947, p. 136; 1956, p. 25). The Sunbury Shale is clearly of Kinderhook age from its contained conodont fauna. In northern Ohio the main problem is to resolve the age and correlation of the relatively unfossiliferous strata between the fossil zone of possible very Late Devonian age in the base of the Bedford Shale and the zone of Early Mississippian conodonts of Kinderhook age in the basal part of the Sunbury Shale.

In parts of Ashtabula and Trumbull Counties in northeastern Ohio,

the Bedford Shale and overlying Berea Sandstone overlap the western edge of the friable medium-grained Cussewago Sandstone (de Witt, 1951, pl. 2). The Bedford and Berea are present in the subsurface of northeastern Ohio and extreme northwestern Pennsylvania where they lie upon the Murrysville sand, the subsurface equivalent of the Cussewago Sandstone. W. H. Hass and I were unable to find the basal fossil zone of the Bedford in northeastern Ohio; therefore, I conclude that the basal strata of the Bedford Shale in Trumbull and Ashtabula Counties are probably slightly younger than the basal fossiliferous zone in the formation at its type area south of Cleveland in Cuyahoga County, Ohio. Although pre-Berea erosion appears to have removed much of the Bedford Shale in parts of western Pennsylvania (Pepper and others, 1954, p. 60), the Berea Sandstone is recognizable above the Murrysville sand in the area as far east as the western part of Allegheny County, west of Pittsburgh (fig. 4).

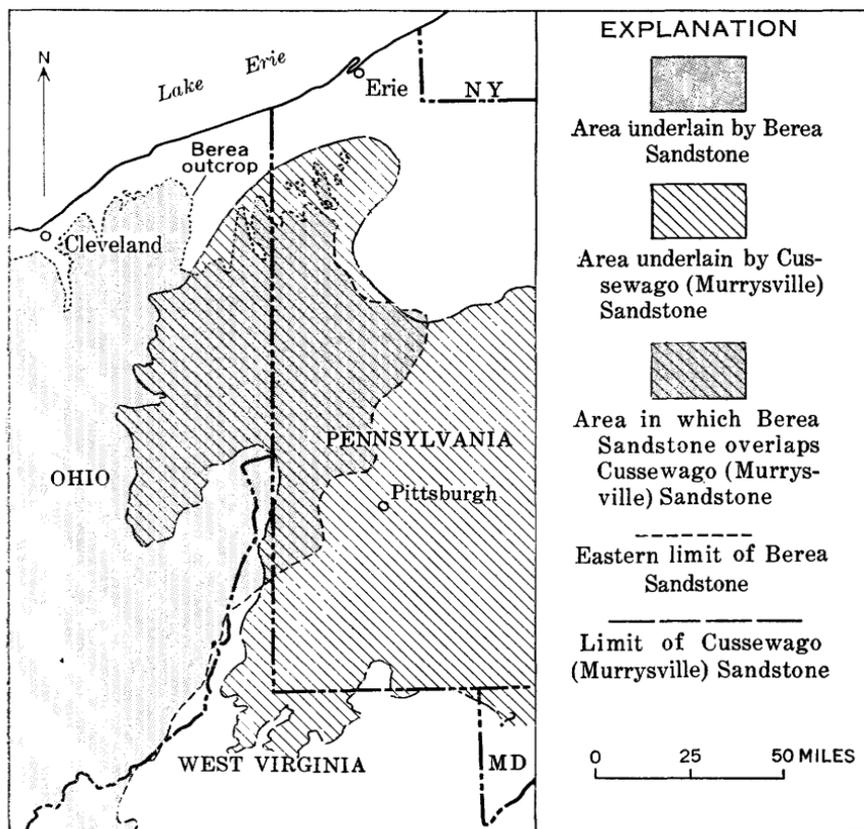


FIGURE 4.—Distribution of the Berea Sandstone and the Cussewago (Murrysville) Sandstone in northeastern Ohio and northwestern Pennsylvania.

The Murrysville sand, which is an eastward-thickening and eastward-coarsening deltaic sandstone (fig. 1), has been traced in the subsurface from northeastern Ohio eastward across Pennsylvania to outcrops in the basal part of the Pocono Formation in the Conemaugh Gorge near Johnstown, Cambria County (Pepper and others, 1954, pl. 14), and from western Pennsylvania eastward to outcrops of the Pocono Formation along the Horse Shoe Curve on the Allegheny Front west of Altoona, Blair County (Bayles, 1949, p. 1695). At the Horse Shoe Curve, the lower part of the Pocono Formation, the unnamed strata below the massive Burgoon Sandstone Member, is a 550-foot sequence of light-gray, tan, white, and grayish-red quartzose sandstone and subgraywacke intercalated with gray, greenish-gray, and red sandy and silty shale and mudrock that contains an Early Mississippian *Adiantites* flora (Read, 1955, p. 8). According to Swartz (1965, p. 24, 29, 30), the Murrysville sand of Bayles (1949) lies in the lower part of the sub-Burgoon strata and contains the *Adiantites* flora. Swartz showed that the *Adiantites* flora ranges from the Murrysville to within a few feet of the base of the Burgoon Sandstone Member where the *Triphylopteris* flora supplants it. Read and Mamay (1964, p. 4) showed that the *Adiantites* flora is of Early Mississippian (Early Carboniferous) age and is present in the Kinderhook Series of the Midcontinent region and in the Lower Mississippian rocks of the Appalachian basin. These data clearly show that the Cussewago (Murrysville) Sandstone is of Kinderhook age.

Read (1955, p. 8) reported an Early Mississippian *Adiantites* flora from shaly strata in the lower part of the Pocono Formation at several localities in the southern part of the Anthracite region of east-central Pennsylvania. As a part of a detailed mapping study, the sequence of red, greenish-gray, tan, brown, and black shale and intercalated white and gray coarse-grained sandstone which contained Read's *Adiantites* flora was named the Spechty Kopf Member by Trexler, Wood, and Arndt (1962). The Spechty Kopf was assigned to the Catskill Formation because it contained red shale. Trexler, Wood, and Arndt also subdivided the overlying Pocono Formation in the western part of the Southern Anthracite coal basin into the Beckville Member and the overlying Mount Carbon Member. The Spechty Kopf is the upper member of the Catskill Formation in this area and is lithologically transitional between the main body of the red beds of the Catskill below and the massive conglomeratic sandstones of the Pocono above. The presence of the *Adiantites* flora in the Spechty Kopf Member demonstrates a Mississippian age for most of the member, although because of the red shale in the Spechty Kopf it is considered a member of the predominantly Devonian Catskill Formation. Lithologically,

the Spechty Kopf is similar to the rocks in the sub-Burgoon Pocono near Altoona. The presence of *Adiantites* in both sequences indicates that they are largely correlative. A flora has not yet been obtained from the Beckville Member of the Pocono in the Anthracite region, and although the relation of this unit to the strata along the Allegheny Front is not fully resolved, Swartz (1965, p. 22) correlated the Beckville with the shaly sub-Burgoon Pocono.

The depositional history and paleogeography of the Cussewago (Murrysville) Sandstone show that it is a part of the vast Pocono delta complex, whose source lay to the east of the Appalachian basin (Pelletier, 1958, p. 1056) and whose distal fringe covered parts of northeastern Ohio (Pepper and others, 1954, p. 59 and pl. 1). The sand body is oldest in central Pennsylvania nearest the source area where the *Adiantites* flora occurs throughout and is probably somewhat younger in northwestern Pennsylvania and northeastern Ohio where the Cussewago is overlapped by all but the oldest strata of the Bedford Shale. These data indicate that, except for the basal fossil zone, most of the Bedford Shale and the younger Berea Sandstone are younger than the Mississippian Cussewago (Murrysville) Sandstone. Because the Bedford and the Berea are underlain by the Cussewago (Murrysville) Sandstone and overlain by the Sunbury Shale, they too must be of Kinderhook age except possibly for the basal fossil zone of the Bedford.

Lithostratigraphic data indicate that the Berea Sandstone may be a temporal equivalent of the lower part of the Beckville Member of the Pocono Formation. In north-central Ohio, the Berea Sandstone is separated from the underlying Bedford Shale by a marked unconformity. At some places, stream channels were cut through the Bedford and into older strata and then were filled by Berea sand. Channel cutting in the Bedford in northern Ohio has been interpreted as a part of an episode of uplift and erosion which affected much of the Appalachian basin at the close of Bedford deposition (Pepper and others, 1954, p. 104). A part of the sheet of Cussewago (Murrysville) Sandstone (the area F sand of Pepper and others, 1954, p. 20, fig. 20) covers much of north-central West Virginia centering in Lewis County. This sand body was uplifted and partly truncated by subaerial erosion in an episode of crustal upwarp during which a large stream, the Gay-Fink River, incised its channel into the sheet of sand. During the subsidence which followed, Berea sand backfilled the channel of the Gay-Fink River, and a transgressing epicontinental sea spread a blanket of fine-grained detritus over the sheet of Murrysville sand and the sand-filled Berea channel (Pepper and others, 1954, p. 77). Trexler, Wood, and Arndt (1961, p. B84) showed that in the Southern Anthra-

cite coal basin, the Beckville Member of the Pocono Formation lies unconformably on the underlying Spechty Kopf Member of the Catskill Formation which was gently folded during the interval of uplift preceding erosion. Only one episode of uplift and erosion appears to have occurred in the Appalachian basin during the Early Mississippian. If this is so, then the sandstones which were deposited upon the erosion surface produced during this episode must be near temporal equivalents. Presumably, therefore, the Berea Sandstone of northern Ohio and the Beckville Member of the Pocono of central Pennsylvania are near temporal equivalents.

AGE OF UNITS IN THE MICHIGAN BASIN

Because the ages assigned to the Bedford Shale, Berea Sandstone, and Sunbury Shale in the Appalachian basin (Pepper and others, 1954, p. 98) can be projected into the Michigan basin with confidence and in the absence of evidence to the contrary, much of the Bedford Shale, all the superjacent Berea Sandstone, and the Sunbury Shale of the Michigan basin are of Early Mississippian age and make up the Kinderhook Series there. Whether the basal part of the Bedford Shale in the Michigan basin is of Devonian or Mississippian age is a moot point at present.

SUMMARY

The data presented in this paper show that (1) *Hymenozonotriletes lepidophytus* Kedo ranges across the Devonian-Mississippian boundary and cannot be used to differentiate Upper Devonian strata from Lower Mississippian strata in the Appalachian basin, (2) the basal few feet of the Bedford Shale in Ohio and Kentucky may be of very Late Devonian or very Early Mississippian age, and (3) most of the Bedford Shale and all the Berea Sandstone and Sunbury Shale are of Early Mississippian (Kinderhook) age.

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