THE AGE, STRATIGRAPHIC RELATIONSHIPS, AND CORRELATION OF THE LOWER PART OF THE OLENTANGY SHALE OF CENTRAL OHIO[1]

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ABSTRACT

The Olentangy Shale of central Ohio (Delaware County) is made up of two distinct stratigraphic units separated by an unconformity. The Upper Olentangy Shale is Upper Devonian in age, and is both lithologically and paleontologically distinct from the Lower Olentangy Shale, which is Middle Devonian (Hamilton) in age. The age distinction is based primarily on a comparison of the ostracod faunas. Other invertebrates from the Lower Olentangy Shale also suggest a Middle Devonian age. The Lower Olentangy Shale correlates with the lower of the exposed units of the Plum Brook Shale of northern Ohio. Most of the invertebrate species of the Lower Olentangy Shale, as well as several ostracod species from the Plum Brook Shale, are illustrated.

INTRODUCTION AND PREVIOUS WORK

N. H. Winchell (1874) named and described the Olentangy Shale for exposures in Delaware County, Ohio. He presented a measured section taken on the east bank of the Olentangy River just south of the city of Delaware. This exposure (fig. 1, locality 2) has since been accepted as the type locality of the formation. Winchell did not find any fossils in the formation and therefore did not commit himself as to its age.

Chiefly on the basis of its stratigraphic position, Orton (1893) believed the shale exposed at Prout's Station in Erie County (Plum Brook Shale) to be equivalent to the Olentangy of Delaware County. Stauffer (1909) considered as equivalent to the Olentangy Shale not only the strata in the Erie County exposures, but also shales in Pickaway and Ross Counties to the south, and in Fleming County, Kentucky. In 1915 and 1916 he further extended the use of the name to include shales underlying the Widder Formation in the vicinity of Arkona, Ontario. Stauffer thus considered the Olentangy Shale of central and southern Ohio to be correlative with what we now know as the Plum Brook and Arkona Shales and therefore to be Middle Devonian in age.

Grabau (1915) maintained that the Olentangy Shale was a facies of the overlying Huron Shale and was therefore of Upper Devonian age. He considered the shales and limestones of Erie County to be early Hamilton in age and recommneded that they be called the Prout series. In 1917, Grabau noted the resemblance of the Olentangy Shale to the Cashaqua Shales of western New York.

Westgate (1926) reviewed both Stauffer's and Grabau's views and, on the basis of his own field investigations in central Ohio, accepted Grabau's interpretation. Lamborn (1927, 1929, and 1938) made extensive field observations from central Ohio south into Kentucky and concluded that the Olentangy Shale was Upper Devonian in age.

Stauffer (1938a) described a conodont fauna of 101 species distributed among 29 genera collected from "gray Devonian shales" in the Thedford-Arkona region of Ontario, and in northwest, north-central, central, and southern Ohio. He concluded that the conodonts proved the correctness of the correlation of these shales and that they were all of Hamilton age. Two months later, Stauffer (1938b) presented an additional list of fossils collected from exposures of the Olentangy Shale in Delaware and Franklin counties in central Ohio. The fossils included in this list were *Sporangites huronensis* Dawson, *Aulopora serpens* Goldfuss, crinoid

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stems and plates, *Ambocoelia* sp. ?, *Chonetes aurora?* Hall, *Chonetes mucronatus?* Hall, *Chonetes* sp., *Productella spinulicosta* Hall, *Spirifer* sp., *Strophalosia truncata* (Hall), *Stropheodonta demissa?* Conrad, *Styliolina fissurella* (Hall), *Tentaculites bellulus* Hall, *Tornoceras* sp., ostracods, conodonts, and fish plates. He concluded (p. 1078) that ". . . the assemblage of species is a Middle Devonian fauna." In the same paper Stauffer pointed out that the Ohio Shale overlaps the Olentangy Shale in the region of the Bellefontaine outlier, and that the Olentangy progressively overlaps the underlying Devonian and Silurian limestones to the south. On the basis of these observations, he concluded (p. 1075) that ". . . the Olentangy shale is disconformable on the Delaware limestone and older formations and in turn is overlain by the Ohio shale with a disconformable contact."

Baker (1942) presented another list of fossils collected from the Olentangy Shale in Delaware county. This list included *Sporangites huronensis* Dawson, *Callixylon newberryi* Dill, *Lopholasma delawarensis*, n. sp., *Streptolasma* sp., *Melocrinus clarkei* Williams, *Reptaria stolonifera* Hall, *Hederella* sp., *Lingula* sp., *Chonetes minutus hemisphericus*, n. var., *Ambocoelia umbonata* (Conrad), *Crania?* sp., *Nucula* sp., *Straparollus* cf. *S. hecale* Hall, *Straparollus* cf. *S. rudis* Hall, *Tentaculites gracilistriatus* Hall, *Manticoceras* sp., *Tornoceras uniangulare* (Conrad), *Orthoceras* sp., *Anaptychus? (Spathiocaris?) emersoni* (Clarke) em. Trauth, *Aspidichthys clavatus* Newberry, fish fragments, ostracods, and conodonts. On the basis of this collection, Baker concluded that the Olentangy Shale was Upper Devonian in age.

Copper *et al.* (1942) correlated the lower part of the Olentangy Shale with the Tully Limestone of New York because of the presence of the coral *Lopholasma* in both formations. In the same paper, the upper part of the Olentangy was correlated with the Cashaqua Shale of New York, although no substantiating evidence was given for this correlation. Cooper was thus the first to recognize the possibility that the Olentangy Shale might be made up of two units of distinctly different age.

Stewart and Hendrix (1945b) reported the occurrence of 36 ostracod species from the Olentangy Shale of central Ohio. Specimens of 29 of these species were illustrated. Regarding the figured specimens, Stewart and Hendrix concluded (p. 98) that ". . . this fauna is not a typical Hamilton assemblage such as those of the Plum Brook and Silica shales. Its composition suggests Upper Devonian, or even Mississippian age. . . ". Of those species which were not illustrated, five, including *Burlella brevispinata* Stewart, *Quasillites? pseudobrevispinata* Stewart and Hendrix, *Punctoprimitia simplex transversa* Stewart and Hendrix, *Ponderodictya ohioensis* Stewart, and *Quasillites obliquus* Coryell and Malkin, were tentatively identified as being forms which also occur in the Plum Brook Shale. Two additional Middle Devonian species, *Bythocypris lucasensis* Stewart and *Ctenoloculina cicatricosa* Warthin, were also reported.

Hoover (1960), in discussing the age of the Olentangy Shale, stated (p. 10) "It is here suggested that the Olentangy, Plum Brook shale, Prout limestone, Silica shale, and Ten Mile Creek dolomite are stratigraphically correlatable, with the reservation that the Olentangy is probably upper Devonian in age as suggested by Stewart (1955, p. 155, Table 3)."

The present work was undertaken to determine whether any portion of the Olentangy Shale is Middle Devonian in age, and if so, what are the stratigraphic relationships and correlatives of that part of the formation.

LOCALITIES

The localities listed below are all described in reference to the Kimball (Localities 9, 10), Delaware (Localities 1, 2), or Powell (Localities 3, 4, 5, 6, 7, 8) 7½-minute topographic quadrangle maps published by the United States Geological Survey. Localities 1–8 are all in Delaware County and are indicated on Figures 2 and 3.

Localities 9 and 10 are in Erie County. Many of the exposures described occur along creeks and so are available only during the dry season in the fall, and even then some must be excavated.

Locality 1.—Exposure along Sugar Run about 0.3 of a mile west of the dam impounding Greenwood Lake. Lat. 40° 18' 37", Long. 83° 3' 38". The Upper and Lower Olentangy Shales and the contact between the two units were examined.

Locality 2.—Major exposure along steep east bank of the Olentangy River about 0.2 of a mile downstream from the mouth of Mill Run and just south of and across the river from the city of Delaware sewage-disposal plant. Lat. 40° 17' 17", Long. 83° 3' 30". The Ohio Shale, the Upper and Lower Olentangy Shales, the Ohio Shale—Upper Olentangy Shale contact and the Upper Olentangy Shale—Lower Olentangy Shale contact were examined. This is the type locality of the Olentangy Shale as first described by Winchell (1874).

Locality 3.—Exposure along stream tributary to the Olentangy River from the west, about 0.4 of a mile east of Delaware County Highway 6 and 1.65 miles north of Hyattsville. Lat. 40° 14' 23", Long. 83° 4' 33". The Lower Olentangy Shale and its contact with the Delaware Limestone were examined.

Locality 4.—Exposures along stream tributary to the Olentangy River from the east, approximately 0.2 of a mile east of Liberty Township road 118, about 1.05 miles south of its intersection with U.S. 23. Lat. 40° 13' 57", Long. 83° 3' 28". This stream flows through the Camp Lazarus Boy Scout Reservation. Good exposures of the Ohio Shale, the Upper and Lower Olentangy Shales, and the Delaware Limestone were examined at this locality. The point on the accompanying map (fig. 2) indicates the position of the Lower Olentangy Shale—Delaware Limestone contact. The Upper Olentangy Shale—Lower Olentangy Shale contact and the Ohio Shale—Upper Olentangy Shale contact were also examined.

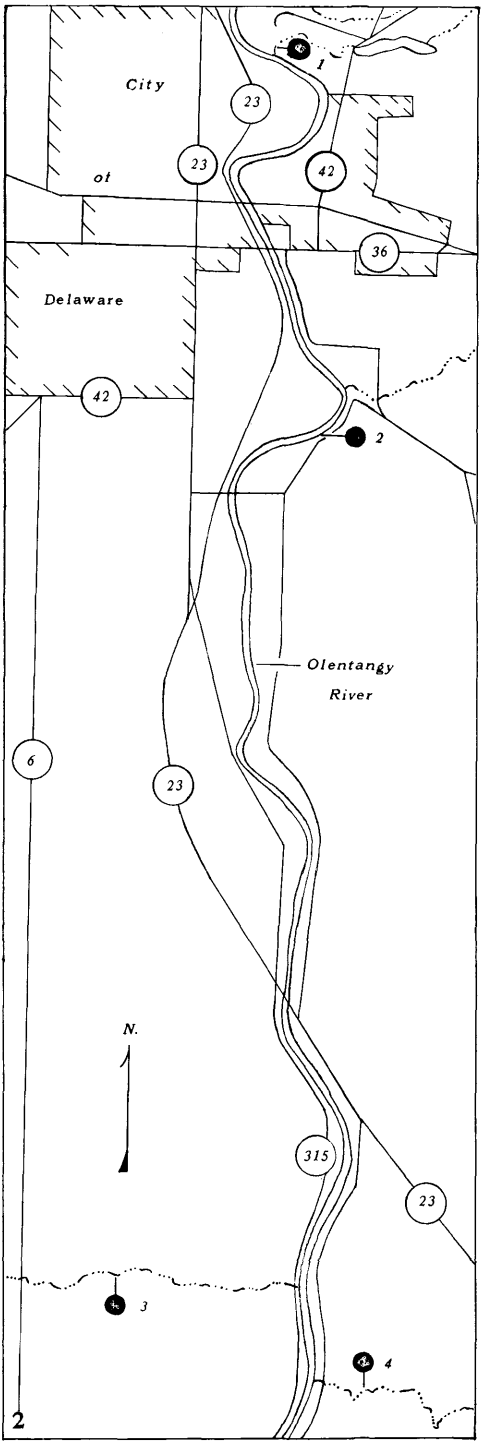
Locality 5.—Exposures along stream tributary to the Olentangy River from the west, 0.25 of a mile south of Delaware County Highway 123 and 0.50 of a mile east of Ohio 315. Lat. 40° 12' 41", Long. 83° 4' 20". Another exposure, Lat. 40° 12' 47", Long. 83° 3' 58", is located about 0.35 of a mile downstream to the east, but it is in the bank of a large recently constructed farm pond and will not be available once the pond completely fills with water. The Ohio Shale, the Upper and Lower Olentangy Shales, the Ohio Shale—Upper Olentangy Shale contact, and the Upper Olentangy Shale—Lower Olentangy Shale contact were examined.

Locality 6.—Exposures along the north branch of a stream tributary to the Olentangy River from the east, 0.75 of a mile west of U.S. 23 and 0.45 of a mile north of Delaware County Highway 124. Lat. 40° 12' 5", Long. 83° 2' 37". This stream is known locally as Lewis Center Run. The Ohio Shale, the Upper and Lower Olentangy Shales, and the Delaware Limestone were examined. The point on the accompanying map (fig. 3) indicates the position of the Upper Olentangy Shale—Lower Olentangy Shale contact. The Ohio Shale—Upper Olentangy Shale contact is located about 900 feet upstream and the Lower Olentangy Shale—Delaware Limestone contact a similar distance downstream.

Locality 7.—Exposures along stream tributary to the Olentangy River from the east, 1.1 miles west of U.S. 23 and 0.37 of a mile north of Orange Township Road 114. Lat. 40° 10' 52", Long. 83° 2' 35". The Ohio Shale, the Upper and Lower Olentangy Shales, the Delaware Limestone, and the contacts between each of these units were examined.

Locality 8.—Exposures along stream tributary to the Olentangy River from the west, about 0.6 of a mile west of Ohio 315 and 0.35 of a mile south of Ohio 750. Lat. 40° 9' 8", Long. 83° 3' 27". This stream is known locally as Bartholomew Run. The Ohio Shale, the Upper Olentangy Shale, the Delaware Limestone, and the contacts between each of these units were examined.

Locality 9.—Stream exposure along tributary of Pipe Creek where it crosses a north-south lane about 0.2 of a mile north of Taylor Road and 0.3 of a mile east



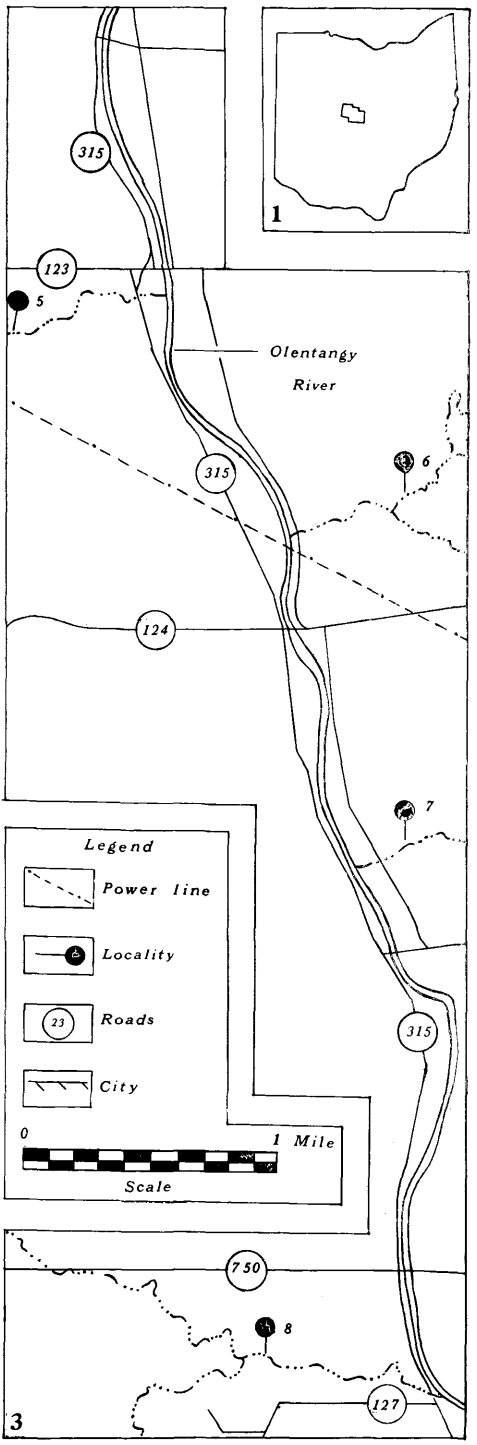


FIGURE 1. Map showing location of Delaware County, Ohio. FIGURE 2. Map showing a portion of central Delaware County and localities referred to in the text. FIGURE 3. Southern continuation of map shown in figure 2.

of Patton Tract Road north of Bloomingville, Erie County. Lat. 41° 21' 23", Long. 82° 43' 22". The lower part of the Prout Limestone, the upper part of the Plum Brook Shale, and the contact between the two units were examined.

Locality 10.—Stream exposure along Plum Brook about 0.1 of a mile south of Fox Road, Erie County. Lat. 41° 22' 15", Long. 82° 40' 41". The lower part of the Prout Limestone and the upper part of the Plum Brook Shale were examined. This exposure is the type locality of the Plum Brook Shale and is within the restricted area of the Plum Brook Ordnance Works currently controlled by the U.S. National Aeronautics and Space Administration.

AGE

The lower portion of the Olentangy Shale is Middle Devonian in age as indicated by its invertebrate fauna listed in Table 1 and illustrated on Figures 4 and 5. Based on the work of Stewart and Hendrix (1945b) and to some degree on the work of Baker (1942), it would appear that the upper part of the Olentangy Shale is Upper Devonian in age. However, the exact position of this unit within the Upper Devonian interval remains to be determined. In terms of invertebrate faunal similarities between the two units of the formation, only three genera,

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EXPLANATION OF FIGURE 4

All specimens figured are in the Orton Museum of Geology at The Ohio State University. All figures ×30.

1. *Aechmina choanobasota* Kesling, 1952; lateral view of right valve, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28661.
2. *Arcyzona diademata* (Van Pelt), 1933; lateral view of right valve, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28662.
3. *Arcyzona bythiclimacota?* Kesling, 1952; lateral view of right valve, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28663.
4. *Bythocyproidea eriensis* Stewart and Hendrix, 1945; right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 10, O.S.U. 28664.

5, 6. *Cornigella immotipedata* Kesling, 1953; 5, right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28665; 6, left lateral view of complete carapace, Plum Brook Shale, locality 9, unit E (Stumm, 1942), O.S.U. 28666.

7, 8. *Ctenoloculina platyzanclota* Kesling, 1953; 7, lateral view of female left valve, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28667; 8, lateral view of female right valve, Plum Brook Shale, locality 9, unit G (Stumm, 1942), O.S.U. 28668.

9, 10. *Ctenoloculina acanthina* Kesling, 1953; 9, lateral view of female right valve, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28669; 10, lateral view of female left valve, Plum Brook Shale, locality 9, unit G (Stumm, 1942), O.S.U. 28670.

11. *Dizygopleura trisinuata* Van Pelt, 1933; right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28671.
12. *Eriella robusta* Stewart & Hendrix, 1945; right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 6, O.S.U. 28672.
13. *Punctoprimitia simplex* (Stewart), 1936; right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28673.
14. *Ponderodictya unicornis* (Van Pelt), 1933; right lateral view of complete carapace, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28674.

15, 16. *Quasillites cavaniferus* (Stewart & Hendrix), 1945; 15, 16, left lateral and right lateral views of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28675.

17. *Quasillites fordei fordei* Coryell & Malkin, 1936; right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28676.

18, 19. *Quasillites dictyinus* Peterson, 1964; 18, right lateral view of complete carapace, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28677; 19, right lateral view of right valve, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28678.

20, 21. *Tetrasacculus magnivelatus* Kesling & McMillan, 1951; 20, right lateral view of complete carapace, Lower Olentangy Shale, locality 6, unit 8, O.S.U. 28679; 21, right lateral view of complete carapace, Plum Brook Shale, locality 10, unit E (Stumm, 1942), O.S.U. 28680.

22, 23. *Thrallella phaseolina* Stewart & Hendrix, 1945; 22, right lateral view of complete carapace, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28681; 23, right lateral view of complete carapace, Plum Brook Shale, locality 9, unit E (Stumm, 1942), O.S.U. 28682.

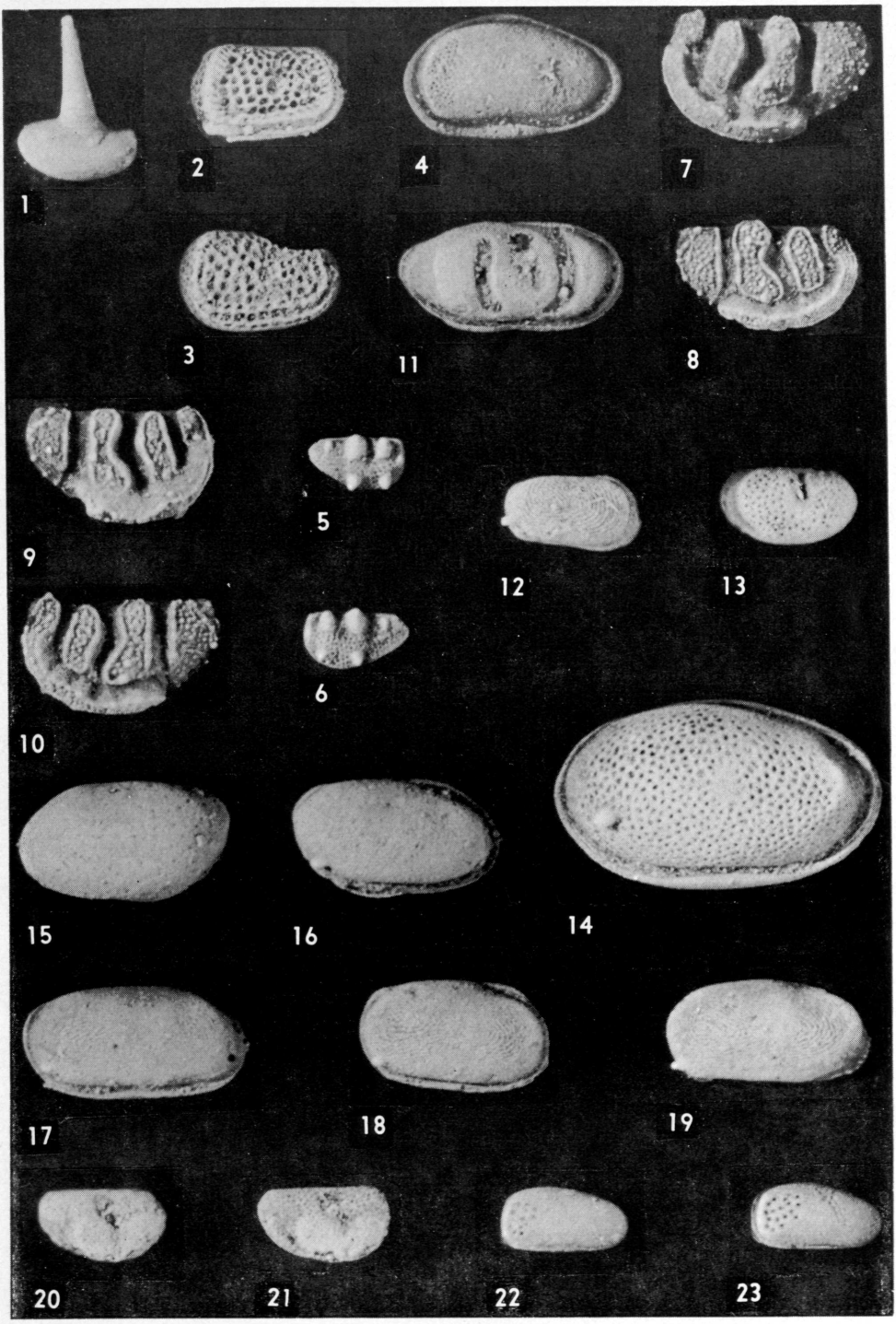

FIGURE 4. Fauna of the Lower Olentangy Shale.

previously reported, have been found common to both. These are *Chonetes*, *Tentaculites*, and *Thrallella*.

Of all the dozen or more localities in Delaware and Franklin Counties where the Olentangy Shale is exposed, it is unfortunate that at the type locality (Locality 2) the preservation of fossils is the poorest, especially in the Middle Devonian portion represented by the lower 15 feet of that section. However, enough identifiable specimens of *Ponderodictya*, *Thrallella*, *Ctenoloculina*, and *Eriella* have have found to confirm the age at that locality. Well-preserved specimens in the Lower Olentangy Shale are relatively easy to obtain at Localities 4 and 6. Good specimens can also be obtained at Localities 1, 5 and 7, when access is permitted by low water levels. However, it should be pointed out that fossil invertebrates are not abundant in any part of the Olentangy Shale. Large samples of shale must be washed to obtain small numbers of fossils.

EXPLANATION OF FIGURE 5

All specimens figured are in the Orton Museum of Geology at The Ohio State University.

1, 2. *Ulrichia acricula* Kesling, 1962; 1, right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28683, ×30; 2, right lateral view of complete carapace, Plum Brook Shale, locality 9, unit E (Stumm, 1942), O.S.U. 28684, ×30.

3, 4. *Ulrichia* sp.; 3, right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28685, ×30; 4, left lateral view of complete carapace, Plum Brook Shale, locality 10, unit E (Stumm, 1942), O.S.U. 28686, ×30.

5, 6. *Ulrichia illinearis* Kesling, 1953; 5, right lateral view of complete carapace, Lower Olentangy Shale, locality 4, unit 10, O.S.U. 28687, ×30; 6, left lateral view of complete carapace, Plum Brook Shale, locality 9, unit E (Stumm, 1942), O.S.U. 28688, ×30.

7, 8. *Genus A* sp.; 7, right lateral view of complete carapace Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28689, ×30; 8, right lateral view of complete carapace, Plum Brook Shale, locality 10, unit E (Stumm, 1942), O.S.U. 28690, ×30.

9–11. *Chonetes* sp.; 9, 10, pedicle and brachial views of complete specimen, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28691, ×3; 11, pedicle view of complete specimen, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28692, ×3.

12, 13. *Sphenophragmus* sp.; 12, 13, brachial and pedicle views of complete specimen, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28693, ×3.

14, 15. *Nuculana rostellata* (Conrad), 1841; 14, right lateral view of pyritized internal mold of complete specimen, Lower Olentangy Shale, locality 2, unit 5, O.S.U. 28694, ×10; 15, left lateral view of pyritized internal mold of complete specimen, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28695, ×10.

16. *Nuculites triqueter* Conrad, 1841; left lateral view of pyritized internal mold of fragment of specimen, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28696, ×10.

17. *Platyceras?* sp.; apical view, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28697, ×10.

18. *Bembexia?* sp.; apertural view, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28698, ×10.

19. *Anematina?* sp.; apertural view, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28699, ×10.

20. *Loxonema?* sp.; apertural view, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28700, ×10.

21. *Anomphalus?* sp.; apical view, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28701, ×10.

22. *Bucanella?* sp.; right lateral view, Lower Olentangy Shale, locality 2, unit 5, O.S.U. 28702, ×10.

23. *Variatella* sp.; lateral view, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28703, ×15.

24. *Tentaculites* sp.; lateral view, Lower Olentangy Shale, locality 4, unit 6, O.S.U. 28704, ×10.

25. *Styliolina* sp.; lateral view, Lower Olentangy Shale, locality 4, unit 4, O.S.U. 28705, ×10.

26–29. *Tornoceras* (*Tornoceras*) *arkonense?* House, 1965; 26, 27, lateral and apertural views of pyritized internal mold, Lower Olentangy Shale, locality 2, ? unit 5, O.S.U. 28706, ×3; 28, 29, lateral and apertural views of pyritized internal mold, Lower Olentangy Shale, locality 6, unit 4, O.S.U. 28707, ×10.

30. *Bactrites arkonesis* Whiteaves, 1898; ventral view of internal mold, Lower Olentangy Shale, locality 5, O.S.U. 28708, ×3.

31, 32. *Incertae sedis;* exterior and interior views, Lower Olentangy Shale, locality 4, unit 6, O.S.U. 28709, ×15.

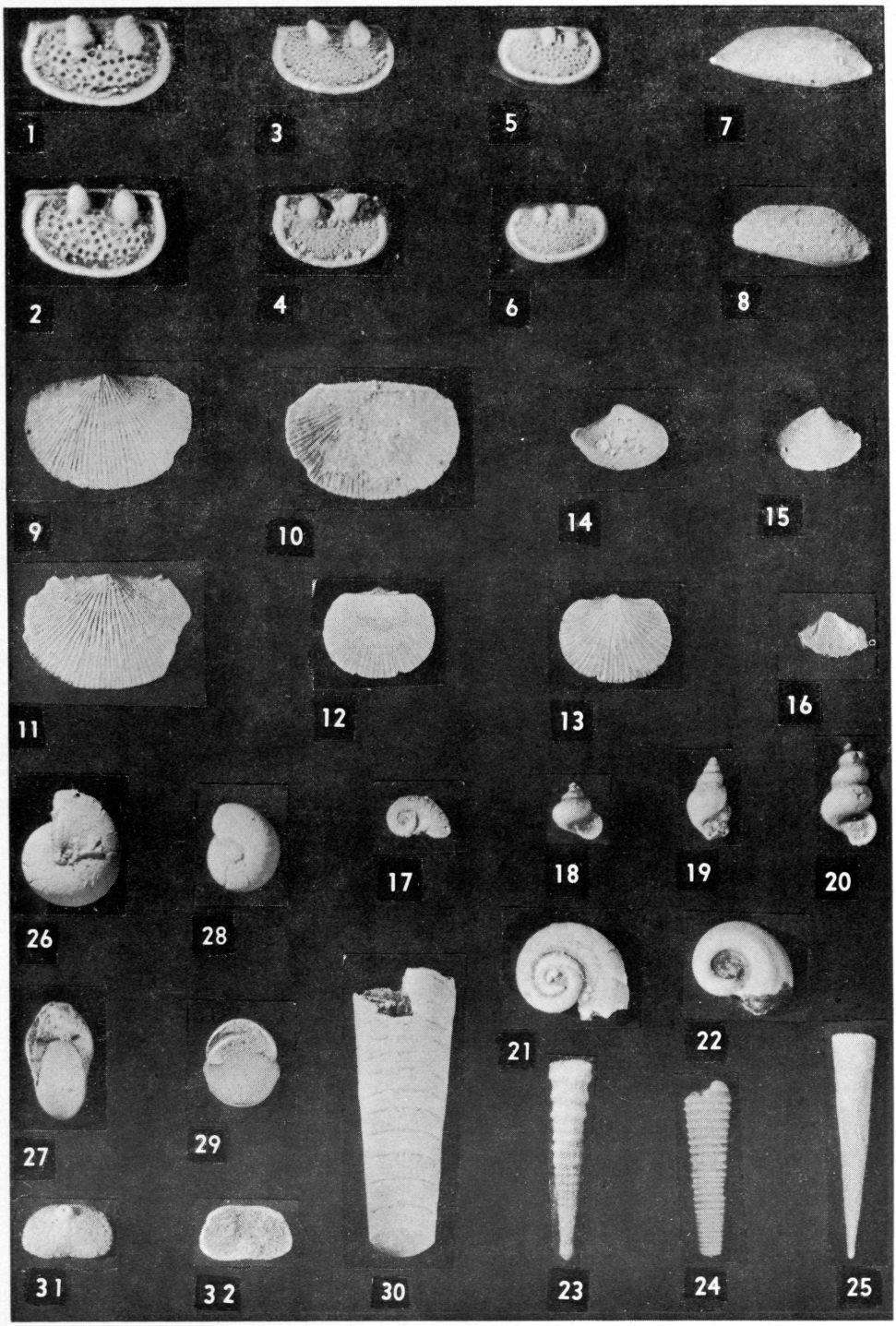

FIGURE 5. Fauna of the Lower Olentangy Shale.

With the exception of the ostracods, the invertebrate fauna of the Lower Olentangy Shale seems to be made up of specimens of smaller-than-average size, when compared to similar forms in the Plum Brook Shale. For this reason, many of the genera listed in Table 1 are not given species designations and, in the case of the gastropods, even generic designations are questionable.

TABLE 1

Comparison of the fauna of the Lower Olentangy Shale with that of the Plum Brook Shale

Taxon	Lower Olentangy Shale	Plum Brook Shale
Brachiopoda		
Chonetes sp.	7*	
Leiorhynchus sp.	7	
Sphenophragmus sp.	7	
Spiriferid	7	
Pelecypoda		
Nuculana rostellata (Conrad)	7	2
Nuculites triqueter Conrad	7	1
Gastropoda		
Anematina? sp.	7	
Anomphalus? sp.	7	
Bembexia? sp.	7	
Bucanella? sp.	7	
Loxonema? sp.	7	
Platyceras? sp.	7	
Cricoconarida		
Styliolina sp.	7	
Tentaculites sp.	7	
Viriatella sp.	7	
Cephalopoda		
Bactrites arkonensis Whiteaves	7	2
Tornoceras (Tornoceras) arkonense? House	7	6
Orthocerid	7	
Annelida		
Scolecodont fragments	7	
Ostracoda		
Aechmina choanobasota Kesling	7	
Arcyzona diademata (Van Pelt)	7	
Arcyzona bythiclimacota? Kesling	7	
Bythocyproidea eriensis Stewart & Hendrix	7	3
Cornigella immotipedata Kesling	7	7
Ctenoloculina acanthina Kesling	7	7
Ctenoloculina platyzanclota Kesling	7	7
Dizygopleura trisinuata Van Pelt	7	3
Eriella robusta Stewart & Hendrix	7	3
Ponderodictya unicornis (Van Pelt)	7	3
Punctoprimitia simplex (Stewart)	4	3
Quasillites cavaniferus (Stewart & Hendrix)	7	3
Quasillites dictyinus Peterson	7	
Quasillites fordei fordei Coryell & Malkin	7	5
Tetrasacculus magnivelatus Kesling	7	7
Thrallella phaseolina Stewart & Hendrix	7	7
Ulrichia acricula Kesling	7	7
Ulrichia illinearis Kesling	7	7
Ulrichia sp. A	7	7
Genus A sp.	7	7
Trilobita		
Trilobite fragments	7	
Incertae sedis	7	

*As first reported by
1. Stauffer, 1909
2. Stauffer, 1916
3. Stewart and Hendrix, 1945a
4. Stewart and Hendrix, 1945b
5. Peterson, 1964
6. House, 1965
7. Tillman, this paper

STRATIGRAPHY

The Olentangy Shale in Delaware County is made up of two distinct units which differ lithologically as well as paleontologically. The Lower Olentangy Shale is a medium-gray (N5) (Goddard *et al.*, 1963) to medium-dark-gray (N4) shale containing fine-grained, continuous, lenticular and concretionary limestone beds up to eight inches thick. Disseminated pyrite and marcasite occur throughout the unit.

The Upper Olentangy Shale is composed predominantly of greenish-gray (5GY 6/1) to dark-greenish-gray (5GY 4/1) shale. Also present, however, are (1) a number of brownish-black (5YR 2/1), carbonaceous, pyritiferous, shale units up to five inches thick, which appear to be geographically continuous at any single exposure; (2) fine-grained, carbonate units up to seven inches thick, which in some exposures appear to be continuous, but in others appear to be lenticular or concretionary; and (3) greenish-gray shale units containing large numbers of irregularly shaped, knobby, pyritiferous, fine-grained, carbonate nodules. The latter shales are the most fossiliferous units in the formation. Pyrite and marcasite occur as disseminations and nodules throughout the Upper Olentangy Shale.

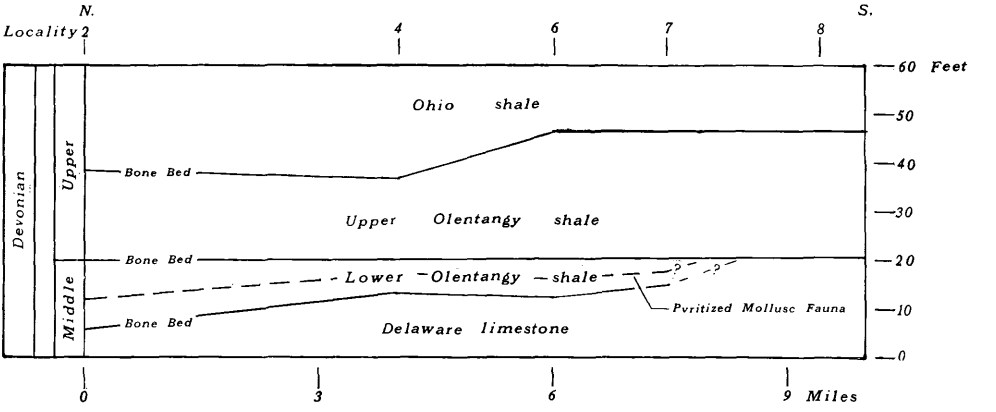

FIGURE 6. Diagramatic north-south cross section showing the relationship of the Lower Olentangy Shale to the Delaware Limestone, Upper Olentangy Shale and Ohio Shale in Delaware County, Ohio. Cross section roughly parallels the course of the Olentangy River. The contact between the Upper and Lower Olentangy Shales was used as the datum plane.

Generalized stratigraphic relationships of the Lower Olentangy Shale are shown in Figure 6. Worthy of note are the following: (1) the Lower Olentangy Shale, which is fifteen feet thick at Locality 2, thins to the south and disappears altogether just north of Locality 8; (2) the Upper Olentangy Shale thickens from about eighteen feet at Locality 2 to about twenty-six feet at Locality 8; and (3) the bone bed, which forms the basal unit of the Upper Olentangy Shale, rests on progressively older units to the south and on progressively younger units to the north. The position of the bone-bed unit, relative to the underlying rocks, is shown by the pyritized mollusc fauna (described in detail in the following section on correlation), which maintains a fairly constant position above the base of the Lower Olentangy Shale, but occurs progressively closer to the contact with the overlying Upper Olentangy Shale as it is traced to the south. Following the work of Wells (1944), the author considers the bone beds to be lag concentrates resulting from uplift and erosion.

More detailed descriptions of the bone beds and other stratigraphic units will be found in the following measured sections of the Olentangy Shale. Sections included are those at the type locality (Locality 2), Camp Lazarus Run (Locality 4), Lewis Center Run (Locality 6), and Bartholomew Run (Locality 8).

Locality 2.—Type locality of the Olentangy Shale in east bank of Olentangy River at Delaware, Delaware County, Ohio.

Unit	Description	Feet	Inches
Ohio Shale:			
	Possible Disconformity		
Upper Olentangy Shale:			
22	Shale, greenish-gray (5GY 6/1) very soft	0	0.5
21	Shale, greenish-gray, hard	2	10
20	Dolomite, medium-bluish-gray (5B 5/1), fine-grained, argillaceous, concretionary, very discontinuous	0	3
19	Shale, dark-greenish-gray (5GY 4/1)	0	10
18	Shale, greenish-gray, limonite stained	3	0
17	Shale, brownish-black (5YR 2/1), with irregular laminae of greenish-gray shale	0	1
16	Shale, greenish-gray, with fine-grained, dolomite nodules in lower part	1	8
15	Dolomite, medium-bluish-gray, fine-grained, lenticular	0	3
14	Shale, greenish-gray, with flat, fine-grained, dolomite concretions in upper part	0	9
13	Shale, brownish-black, with laminae of greenish-gray shale	0	1
12	Shale, greenish-gray	0	2
11	Shale, brownish-black, with laminae of greenish-gray shale	0	1
10	Shale, greenish-gray	0	4
9	Shale, brownish-black, with iron-sulfide nodules and a few irregular greenish-gray-shale laminae near top	0	5
8	Shale, greenish-gray, with dolomite nodules	0	8
7	Shale, brownish-black, with iron-sulfide nodules and greenish-gray shale laminae near top and bottom	0	2
6	Shale, greenish-gray with small knobby, fine-grained dolomite nodules concentrated in lower 4 inches	1	6
5	Shale, greenish-gray	1	0
4	Shale, brownish-black, with greenish-gray laminae near top and bottom	0	1
3	Shale, greenish-gray	1	4
2	Shale, greenish-gray to olive-gray (5Y 4/1), with small iron-sulfide and knobby dolomite nodules, especially in lower part	2	4
1	Shale, upper 0.5 inch greenish-gray, well-indurated; lower 0.5 inch very light-gray (N8), soft, sticky clay. Both parts of unit contain an abundance of unsorted, rounded bone fragments, teeth, fragmental conodonts, and phosphate nodules. *Ancyrodella*, *Ancyrognathus*, *Icriodus*, *Palmatolepis* and *Polygnathus* are characteristic conodont genera	0	1
	Total	17	11.5
	Disconformity		
Lower Olentangy Shale:			
15	Shale, medium-dark-gray (N4)	0	10
14	Limestone, medium-gray (N5), fine-grained, concretionary	0	2
13	Shale, medium-dark-gray	1	9
12	Limestone, medium-gray, fine-grained, concretionary	0	4
11	Shale, medium-dark-gray	1	4
10	Limestone, medium-gray, fine-grained, concretionary	0	2
9	Shale, medium-dark-gray	1	5
8	Limestone, medium-gray, fine-grained, lenticular	0	3
7	Shale, medium-dark-gray	1	9
6	Limestone, medium-gray, fine-grained, lenticular	0	3
5	Shale, medium-dark-gray, with small pyritized molluscs in lower part	3	3
4	Limestone, medium-gray, fine-grained, continuous, with a few ostracods	0	4
3	Covered	1	10
2	Limestone, medium-gray, fine-grained, continuous	0	5
1	Covered	1	0
	Total	15	1
	Disconformity		
Delaware Limestone:			

Locality 4.—Exposures along a tributary to the Olentangy River flowing through Camp Lazarus Boy Scout Reservation, Delaware County, Ohio.

Unit	Description	Feet	Inches
Ohio Shale:			
	Possible Disconformity		
Upper Olentangy Shale:			
19	Shale, greenish-gray (5GY 6/1), hard	2	6
18	Covered	0	6
17	Shale, greenish-gray	1	0
16	Shale, brownish-black (5YR 2/1)	0	0.5
15	Shale, greenish-gray	1	7
14	Limestone, greenish-gray, fine-grained, appears continuous	0	4
13	Shale, greenish-gray	0	6
12	Limestone, greenish-gray, fine-grained, very discontinuous	0	3
11	Shale, greenish-gray	0	11
10	Shale, brownish-black	0	1
9	Shale, greenish-gray	0	6
8	Shale, brownish-black	0	6
7	Shale, greenish-gray	1	0
6	Shale, brownish-black	0	3
5	Shale, greenish-gray	1	4
4	Shale, greenish-gray with small knobby, fine-grained limestone nodules	1	0
3	Shale, grenish-gray	2	6
2	Shale, greenish-gray with small, knobby, fine-grained limestone nodules	0	6
1	Shale, upper 0.5 inch greenish-gray well-indurated; lower 0.5 inch, very light-gray (N8), soft, sticky clay. Both parts of unit contain an abundance of unsorted, rounded bone fragments, teeth, fragmental conodonts, and phosphate nodules. *Ancyrodella*, *Ancyrognathus*, *Icriodus*, *Palmatolepis*, and *Polygnathus* are characteristic conodont genera	0	1
	Total	15	4.5
	Disconformity		
Lower Olentangy Shale:			
10	Shale, medium-dark-gray (N4)	0	8
9	Limestone, medium-gray (N5), fine-grained, lenticular	0	2
8	Shale, medium-dark-gray	0	6
7	Limestone, medium-gray, fine-grained lenticular	0	3
6	Shale, medium-dark-gray	1	0
5	Limestone, medium-gray, fine-grained, continuous, with a few ostracods	0	4
4	Shale, medium-dark-gray, with pyritized molluscs	0	5
3	Limestone, medium-gray, fine-grained, continuous	0	2
2	Shale, medium-dark-gray, partly covered	3	4
1	Shale, medium-dark-gray, with marcasite, bone fragments, teeth, fragmental conodonts, silicified and pyritized bryozoans, brachiopods, gastropods and ostracods, chert fragments, and a few quartz grains. *Icriodus* and *Polygnathus* are characteristic conodont genera	0	2
	Total	7	0
	Disconformity		
Delaware Limestone:			

Locality 6.—Exposures along the north branch of Lewis Center Run 0.75 of a mile west of U. S. 23, Delaware County, Ohio.

Unit	Description	Feet	Inches
Ohio Shale:			
	Possible Disconformity		
Upper Olentangy Shale:			
32	Shale, greenish-gray (5GY 6/1), hard in upper 1½ feet, with widely spaced medium-bluish-gray (5B 5/1) dolomite concretions about 3½ feet from the top	4	10

Unit	Description	Feet	Inches
31	Shale, brownish-black (5YR 2/1), with laminae of greenish-gray shale	0	0.5
30	Shale, dark-greenish-gray (5GY 4/1), hard	0	5.5
29	Shale, greenish-gray	0	5
28	Shale, dark-greenish-gray, hard	0	4
27	Shale, greenish-gray	2	2
26	Shale, brownish-black	0	0.5
25	Shale, greenish-gray	1	0
24	Limestone, medium-bluish-gray, fine-grained, concretionary, very discontinuous	0	1.5
23	Shale, greenish-gray, heavily iron-stained near bottom	0	11
22	Limestone, medium-bluish-gray, fine-grained, appears continuous	0	6
21	Shale, greenish-gray, with many small limestone nodules	0	5
20	Limestone, medium-bluish-gray, fine-grained, appears continuous	0	1
19	Shale, greenish-gray	0	6
18	Shale, brownish-black	0	1
17	Shale, greenish-gray	0	5
16	Shale, brownish-black	0	0.5
15	Shale, greenish-gray	0	4
14	Shale, brownish-black	0	1
13	Shale, greenish-gray	0	2
12	Shale, brownish-black	0	5
11	Shale, greenish-gray	0	11
10	Shale, brownish-black	0	3
9	Shale, greenish-gray	1	4
8	Shale, greenish-gray, with limestone nodules	1	0
7	Shale, greenish-gray	0	11
6	Shale, brownish-black	0	2
5	Shale, greenish-gray to dark-greenish-gray (5G 4/1), with small, fine-grained, knobby limestone nodules	5	3
4	Shale, brownish-black	0	1
3	Shale, greenish-gray	1	0
2	Shale, greenish-gray, with small, fine-grained, knobby limestone nodules	2	3
1	Shale, upper 0.5 inch, greenish-gray, well-indurated; lower 0.5 inch, very, light-gray (N8), soft, sticky clay. Both parts of unit contain an abundance of unsorted, rounded bone fragments, teeth, fragmental conodonts, and phosphate nodules. *Ancyrodella*, *Ancyrognathus*, *Icriodus*, *Palmatolepis*, and *Polygnathus* are characteristic conodont genera	0	1
	Total	26	7.5

Disconformity

Lower Olentangy Shale:

8	Shale, medium-dark-gray (N4)	0	11
7	Limestone, medium-gray (N5), fine-grained, concretionary	0	2
6	Shale, medium-dark-gray	1	8
5	Limestone, medium-gray, fine-grained, concretionary	0	5
4	Shale, medium-dark-gray, with pyritized molluscs in lower part, partly covered	2	10
3	Limestone, medium-gray, fine-grained, continuous, with a few ostracods	0	3
2	Shale, medium-dark-gray, partly covered	2	1
1	Shale, medium-dark-gray; with marcasite, bone fragments, teeth, fragmental conodonts, silicified and pyritized bryozoans, brachiopods, gastropods and ostracods, chert fragments, and a few quartz grains. *Icriodus* and *Polygnathus* are characteristic conodont genera	0	1
	Total	8	5

Disconformity

Delaware Limestone:

Locality 8.—Exposures along Bartholomew Run about 0.6 of a mile west of Ohio 315, Delaware County, Ohio.

Unit	Description	Feet	Inches
Ohio Shale:			
	Possible Disconformity		
Upper Olentangy Shale:			
32	Shale, greenish-gray (5GY 6/1) with thin band of brownish-black (5YR 2/1) shale 1 inch from top	0	5
31	Shale, brownish-black, with sulfide particles near top	0	1
30	Shale, greenish-gray	3	8
29	Limestone, medium-bluish-gray (5B 5/1), fine-grained, concretionary, discontinuous, with sulfide nodules	0	5
28	Shale, greenish-gray	1	3
27	Shale, brownish-black, with greenish-gray laminae	0	0.5
26	Shale, greenish-gray	2	11
25	Shale, brownish-black	0	1
24	Shale, greenish-gray	1	9
23	Limestone, medium-gray (N5) to medium-bluish-gray, fine-grained, apparently continuous	0	7
22	Shale, greenish-gray	0	2
21	Limestone, fine-grained, nodular	0	1
20	Shale, greenish-gray	0	5
19	Shale, brownish-black with laminae of greenish-gray shale near top and bottom	0	1
18	Shale, greenish-gray	0	5
17	Shale, brownish-black with laminae of greenish-gray shale near top and bottom	0	2
16	Shale, greenish-gray	0	3
15	Shale, brownish-black with laminae of greenish-gray shale near top and bottom	0	1
14	Shale, greenish-gray	0	3
13	Shale, brownish-black with laminae of greenish-gray shale near top	0	5
12	Shale, greenish-gray	1	0
11	Shale, brownish-black	0	2
10	Shale, greenish-gray with many small, fine-grained, nobby, limestone nodules	1	5
9	Limestone, medium-gray to medium-bluish-gray, fine-grained, apparently continuous	0	4
8	Shale, greenish-gray, with 3 inches of hard dark-greenish-gray (5GY 4/1) shale in middle	1	7
7	Shale, brownish-black	0	2
6	Shale, greenish-gray, with many small, fine-grained, knobby, limestone nodules	2	6
5	Shale, greenish-gray	1	8
4	Shale, brownish-black	0	3
3	Shale, greenish-gray with small, fine-grained, limestone nodules	1	2
2	Shale, greenish-gray (5G 6/1) to light-bluish-gray (5B 7/1) with scattered sulfide nodules, partly covered	1	11
1	Sulfide and chert with some greenish-gray shale, bone fragments, teeth, fragmental conodonts, silicified invertebrates, and a few quartz grains. *Ancyrodella*, *Ancyrognathus*, *Icriodus*, and *Polygnathus are* characteristic conodont genera	0	2
	Total	25	10½
	Disconformity		
Delaware Limestone:			

CORRELATION

As indicated in Table 1, the author has distinguished 24 species distributed among 30 genera of invertebrates in the Lower Olentangy Shale. Twenty of these 24 species occur also in the Plum Brook Shale in Erie County. In addition, 23 of the 30 genera reported from the Lower Olentangy Shale have also been reported from the Plum Brook Shale. Based on (1) similarity of invertebrate faunas,

(2) similarity of lithology, and (3) similarity of stratigraphic position relative to the Delaware Limestone, the Lower Olentangy Shale would appear to be correlative with the Plum Brook Shale.

In the Olentangy Shale, at a position varying from two and one-half to four feet above the Delaware Limestone (fig. 6), there is a unit, six inches to one foot thick, in which fossils are more abundant than elsewhere. This unit is characterized by the presence of pyritized molluscs, including *Nuculana rostellata* (Conrad), *Nuculites triqueter* Conrad, *Bactrites arkonensis* Whiteaves, *Tornoceras* (*Tornoceras*) *arkonense* House, and several gastropods.

A similar assemblage was reported by Stauffer (1916) in the Plum Brook Shale, occurring about twenty-five feet below the base of the Prout Limestone, and in the Arkona Shale of Ontario, at a similar distance below the Encrinal Limestone (Hungry Hollow Formation). He divided the Plum Brook Shale into ten units and reported the whole pyritized assemblage as occurring in unit 3, eight feet above the base of the exposed section. Stauffer applied the name "*Bactrites* horizon" to his unit 3, which he reported as being approximately six inches thick. He also reported the presence of *Nuculites triqueter* in unit 5.

Stauffer (1916) reported the occurrence of a diversified and abundant fauna in his unit 2, which included approximately three feet of shale below the "*Bactrites* horizon." The equivalent unit in the Lower Olentangy Shale, while fossiliferous, does not show such diversity and abundance. Concerning his unit 4 (the approximately ten feet of shale overlying the "*Bactrites* horizon"), Stauffer stated (p. 478) that "The fossils are probably rare in most of it and appear to be in streaks or layers." Except for the word "probably", this statement would accurately describe the nature of the Lower Olentangy above the position of the pyritized mollusc fauna, as observed in Delaware County.

Stumm (1942) divided the Plum Brook Shale into seven zones. He reported *Nuculana rostellata*, *Tornoceras uniangulare* and *Bactrites arkonensis* as occurring in his zone A (Stauffer's units 4, 3, 2, and part of 1) and *Nuculites triqueter* in his overlying zone B (Stauffer's unit 5). Zone A was the lowest exposed unit of the Plum Brook Shale. House (1965), p. 81) placed Stumm's specimen of *Tornoceras uniangulare* (Stumm, 1942, pl. 8, fig. 46) in his new species *Tornoceras* (*Tornoceras*) *arkonense*.

The author has examined the exposures of the Plum Brook Shale at its type locality and along the tributary to Pipe Creek. In Stumm's zones C–G, the ostracod fauna is considerably more varied than is that of the Lower Olentangy Shale, both in terms of genera and species. It seems doubtful, therefore, that the Lower Olentangy Shale would be correlative with any of these units. Unit A is not exposed at the present time and its ostracod fauna is not well known. However, based on the work of Stauffer (1916) and of Stumm (1942), we do know that a pyritized mollusc fauna occurs in Stumm's unit A. A similar fauna occurs in the Lower Olentangy Shale. On this basis, the author suggests that the Lower Olentangy Shale of Delaware County may be correlative with and represent a southern continuation of Stumm's zone A of the Plum Brook Shale.

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