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CHARLES D. WALCOTT, DIRECTOR

CONTRIBUTIONS TO DEVONIAN PALEONTOLOGY

1903

BY

HENRY SHALER WILLIAMS
AND
EDWARD M. KINDLE

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1905

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ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., May 31, 1904.

SIR: I have the honor to transmit herewith the manuscript of a report entitled "Contributions to Devonian Paleontology, 1903," by Henry Shaler Williams and Edward M. Kindle, and to recommend its publication as a bulletin. The report consists of two parts: I. Fossil faunas of the Devonian and Mississippian ("Lower Carboniferous") of Virginia, West Virginia, and Kentucky. II. Fossil faunas of the Devonian sections of central and northern Pennsylvania.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

CONTRIBUTIONS TO DEVONIAN PALEONTOLOGY, 1903.

PART I.

FOSSIL FAUNAS OF THE DEVONIAN AND MISSISSIPPIAN ("LOWER CARBONIFEROUS") OF VIRGINIA, WEST VIRGINIA, AND KENTUCKY,

BY

HENRY SHALER WILLIAMS and EDWARD M. KINDLE.

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CONTRIBUTIONS TO DEVONIAN PALEONTOLOGY, 1903.

PART I.—FOSSIL FAUNAS OF THE DEVONIAN AND MISSISSIPPIAN ("LOWER CARBONIFEROUS") OF VIRGINIA, WEST VIRGINIA, AND KENTUCKY.

By H. S. WILLIAMS and E. M. KINDLE.

INTRODUCTION.

By H. S. WILLIAMS.

The investigations herein reported were begun for the purpose of ascertaining the nature of the changes in sedimentation, in fossils, and in sequence of faunas southward along the Devonian formations in the southern Appalachians. Collections were made by the senior author in southern Virginia and eastern Kentucky in 1895, and the results of the preliminary study of the fossils were reported in a paper read before the Geological Society of America in December, 1896.[a]

In southern Virginia (at Bigstone Gap) the Devonian is represented by a continuous black shale, which probably runs upward beyond the stratigraphic horizon at which Carboniferous faunas appear in other regions. In east-central Kentucky the black shale, supposed to be in large part Devonian, continues upward beyond the horizon at which the earliest Carboniferous faunas appear. In neither the Bigstone Gap nor the Irvine (Ky.) sections was any trace of the Chemung fauna of New York seen. At several places, at the base of the black shales, the latest fauna appears to be no younger than Oriskany, and suggested that either there was an unconformity at the base or a black shale sedimentation continued during post-Oriskany Devonian time. Evidence of the unconformity at the base of the black shale is furnished by the sections at Brooks station, 15 miles south of Louisville, and at Huber, Bullitt County, Ky.

In order to demonstrate the conditions intermediate between those represented by the typical northern sections and by the sections in the southern Appalachians, Dr. E. M. Kindle in 1898 made a special

[a] On the southern Devonian formations: Am. Jour. Sci., 4th ser., vol. 3, 1897, pp. 395–405.

examination of the Devonian sections in Kentucky, West Virginia, and Virginia. Additional collections were thus obtained, and later all the material was studied together and the faunules listed and compared. The original identifications in the following paper were made by Doctor Kindle. They have been reviewed by the senior author, who is responsible for the discussions which follow the statistics.

KENTUCKY SECTIONS.

By E. M. KINDLE.

The Kentucky sections examined furnished faunules from the following localities:

Sections examined in Kentucky.

1355 A. Bear Grass Creek quarries near Louisville, Ky.
1357 A. Jeffersonville, Clark County, Ind.
B. Jeffersonville, Indiana side, near Government jetty.
C. South end of Pittsburg, Cincinnati, Chicago and St. Louis Railway bridge, Louisville, Ky.
1365 A. Brooks, Bullitt County, Ky.
B. Button Mold Knob, three-fourths of a mile northeast of Brooks.
C. One mile west of Brooks station.
1367 A. Railroad cut, one-fourth of a mile south of Huber, Bullitt County, Ky.
1368 A. Quarry at Clermont, Bullitt County, Ky.
B. Ravine about one-fourth of a mile southeast of quarry, Clermont, Ky.
C. Section at Deerlick Knob, Bullitt County.
1371 A. West of town of New Haven, Nelson County, Ky., on bank of Rolling Fork.
B. About 5 miles south of New Haven along the pike at Muldrows Hill.
1372 A. Northwest of Riley station, Marion County, Ky.
B. South of Riley station.
1373 A. About three-fourths of a mile west of Parksville, Boyle County, Ky.
B. An old quarry in the "Knobstone" sandstone, 1½ miles west of Parksville.
1374 A. Lone Knob, near Junction City, Boyle County, Ky.
1375 A. Crab Orchard, Lincoln County, Ky.

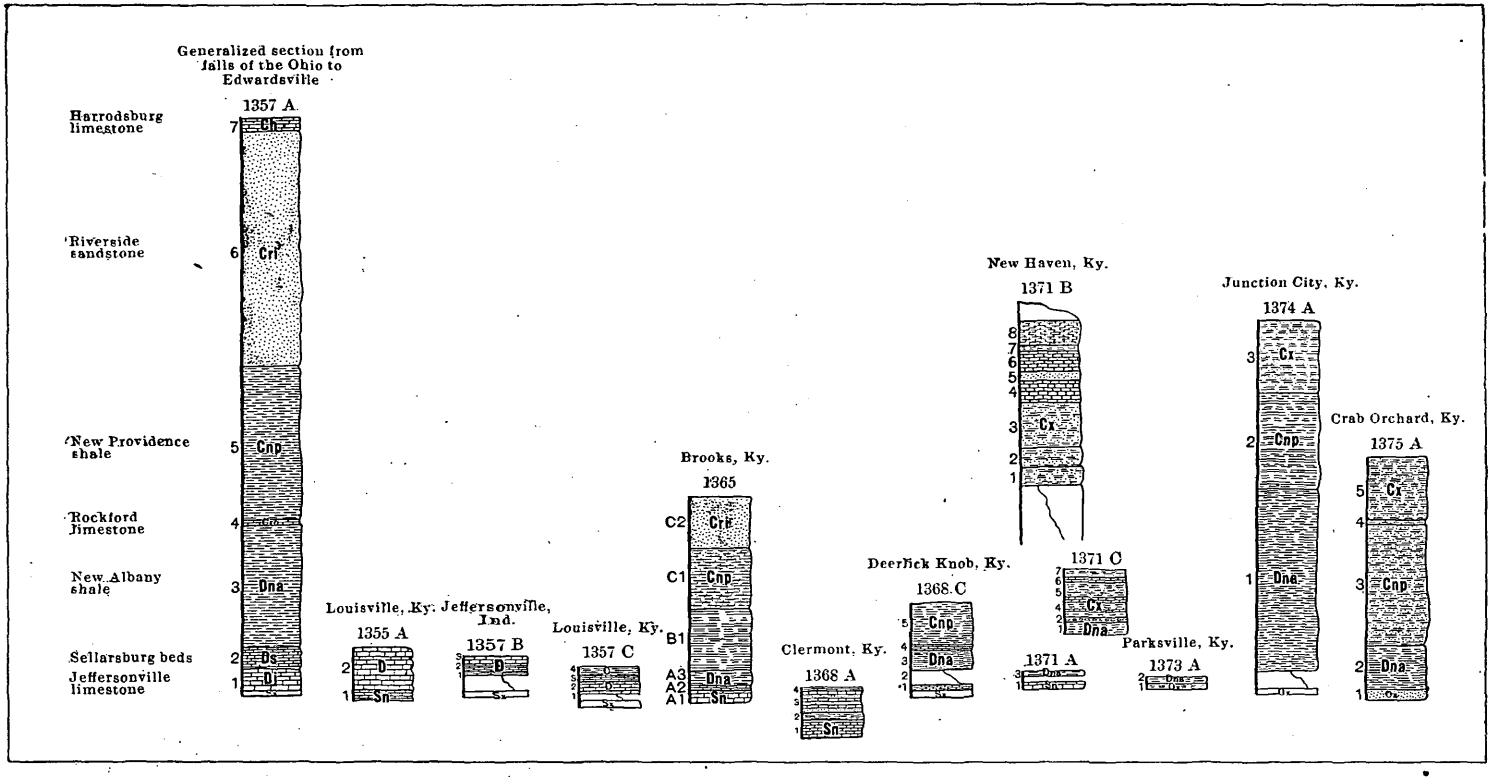
BEAR GRASS CREEK QUARRIES, NEAR LOUISVILLE, KY.

Just east of Louisville the Niagara limestone is extensively quarried along the banks of Bear Grass Creek. The tops of the hills in the vicinity of the quarries are usually capped with from 10 to 15 feet of Devonian limestone. The following section is exposed at the quarry south of the institution for the blind:

Section 1355 A, on Bear Grass Creek, Kentucky.

	Feet.
2. White to light gray limestone (Devonian)	10
1. Light bluish-gray arenaceous limestone (Niagara)	35

In the Niagara beds (1) corals are common, but other fossils are scarce and difficult to obtain. The following species were collected from the lower part of the section:



SECTIONS IN INDIANA AND KENTUCKY NEAR LOUISVILLE.

Faunule of zone 1 of section 1355 A, on Bear Grass Creek, Kentucky.

[c, common; r, rare.]

1. Strombodes striatus (c).
2. S. sp. (c).
3. Cladopora sp. (r).
4. Halysites catenulatus (c).
5. Lyellia papillata (c).
6. Heliolites sp. (c).
7. Stromatopora sp. (r).
8. Cornulites proprius (r).
9. Dalmanella elegantula (r).
10. Conchidium nysius (r).
11. Uncinulus cf. stricklandi (r).
12. Atrypa reticularis (r).
13. A. reticularis var. niagarensis (r).
14. Dalmanites vigilans (r).

In the upper 10 feet of the section fossils are abundant. *Spirifer gregarius* Clapp occurs in great profusion, and, with a few species of corals, furnishes the greater part of the faunule in some of the strata. The fossils identified from these beds are as follows:

Faunule of zone 2 of section 1355 A, on Bear Grass Creek, Kentucky.

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (c).
2. Pleurodictyum problematicum (r).
3. Crinoid stems (c).
4. Polypora sp. (r).
5. Stropheodonta demissa (c).
6. S. hemispherica (r).
7. S. (Leptostrophia) perplana (r).
8. Orthothetes chemungensis var. arctostriatus (r).
9. Chonetes mucronatus (r).
10. Schizophoria striatula (c).
11. Pentamerella arata (r).
12. Eunella lincklæni (r).
13. Atrypa reticularis (a).
14. Spirifer acuminatus (r).
15. S. byrnesi (r).
16. S. gregarius (a).
17. S. varicosus (r).
18. Conocardium trigonale (r).
19. Aviculopecten princeps (r).
20. Platyceras carinatum (r).
21. P. dumosum (r).
22. P. echinatum (r).
23. Proetus crassimarginatus (c).
24. Phacops cristata var. pipa (r).

OHIO FALLS AND EDWARDSVILLE SECTIONS.

The Niagara limestones, which are so well exposed just east of Louisville, are brought below the bed of the Ohio at the falls by the westerly dip, which is probably about 25 or 30 feet to the mile. A connected section from the Falls of the Ohio to Edwardsville, on the Indiana side of the river, shows the following beds:

Generalized section 1357 A, from Falls of the Ohio to Edwardsville.

	Feet.
7. Gray limestone (Harrodsburg)	60
6. Massive to shaly sandstone and sandy shales (Riverside), with 1 to 10 feet of oolitic limestone in upper part	200
5. Blue arenaceous shales (New Providence)	125
4. Fine-grained limestone (Rockford), breaking with conchoidal fracture	3
3. Fissile black carbonaceous shale (New Albany)	104
2. Argillaceous blue-gray limestone (Sellarsburg beds)	15
1. Light-gray limestone (Jeffersonville)	20

Fossils were obtained from the Jeffersonville limestone at the exposure on the north bank of the river, about half a mile below the Pittsburg, Cincinnati, Chicago and St. Louis Railway bridge (1357 A1).

The Jeffersonville limestone is exposed at low-water mark, near the Government jetty on the Indiana side of the river. Fossils were obtained from each of the the three zones of this limestone given below:

Section 1357 B, Jeffersonville limestone on north side of Ohio River.

	Feet.
3. Light-gray limestone	6
2. Hard gray limestone	2
1. Exposed at low water	3

Near the south end of the Pittsburg, Cincinnati, Chicago and St. Louis Railway bridge, in Louisville, Ky., the fine-grained calcareous sandstones lying below the black shale are quarried for cement. Three or 4 feet of rather pure limestone separate these sandy beds from the black shale at the upper end of the canal. The section is composed of the following zones:

Section 1357 C, at Louisville, Ky.

	Ft.	in.
4. Black shale (at upper end of canal)	1	
3. Light-gray limestone	3	6
2. Cement beds (Sellarsburg)	8	
1. Jeffersonville limestone (not exposed).		

The faunules collected from the rocks at the Ohio Falls and in the vicinity are as follows:

Faunule of zone 1 of section 1357 A, at Jeffersonville, Clark County, Ind.

[a, abundant; c, common; r, rare.]

1. Zaphrentis gigantea (c).
2. Z. ungula (c).
3. Blothrophyllum decorticatum (c).
4. Diphyphyllum sp.
5. Thecia minor (c).
6. Favosites hemisphericus (c).
7. Michelinia cylindrica (c).
8. Discina sp. (r).
9. Stropheodonta demissa (c).
10. S. hemispherica (c).
11. S. (Leptostrophia) perplana (r).
12. Chonetes sp. (r).
13. Productella spinulicosta (r).
14. Orthis cf. livia (r).
15. Schizophoria striatula (r).
16. Gypidula romingeri var. indianensis (r).
17. Atrypa aspera (r).
18. A. reticularis (a).
19. Cyrtina hamiltonensis (r).
20. Spirifer arctisegmentus (r).
21. S. euruteines (r).
22. S. byrnesi (r).
23. S. gregarius (a).
24. Conocardium trigonale (r).
25. Trochonema rectilatera (r).
26. Platyceras dumosum (r).
27. Platyostoma lineatum (r).
28. Proetus canaliculatus (r).

Faunule of zone 1 (Jeffersonville limestone) of section 1357 B, on north side of Ohio River.

[a, abundant; c, common; r, rare.]

1. Zaphrentis gigantea (a).
2. Blothrophyllum sp. (c).
3. Favosites hemisphericus (c).
4. Syringopora sp. (c).
5. Stropheodonta demissa (c).
6. S. (Leptostrophia) perplana (r).
7. Pentamerella arata (r).
8. Eunella lincklæni (c).
9. Spirifer gregarius (r).
10. S. varicosus (r).
11. Conocardium cuneus (a).
12. Modiomorpha mytiloides (r).
13. Pleurotomaria sp. (r).
14. Holopea sp. (r).
15. Proetus crassimarginatus (c).
16. P. microgemma (r).

Faunule of zone 2 of section 1357 B, on north side of Ohio River.

[a, abundant; c, common; r, rare.]

1. Zaphrentis gigantea (c).
2. Cyathophyllum rugosum (c).
3. Stropheodonta demissa (c).
4. S. (Leptostrophia) perplana (r).
5. Orthothetes chemungensis (r).
6. Chonetes mucronatus (c).
7. Schizophoria cf. striatula (r).
8. Atrypa reticularis (c).
9. Cyrtina hamiltonensis (r).
10. Spirifer gregarius (a).
11. Glyptodesma occidentale (r).
12. Conocardium cuneus (a).
13. Actinopteria boydi (r).
14. Ptychodesma sp. nov. (r).
15. Modiomorpha affinis (a).
16. M. mytiloides (a).
17. Turbo shumardi (c).
18. Callonema bellatulum (c).
19. C. cf. imitator (c).
20. Proetus crassimarginatus (c).
21. Dalmanites anchiops var. sobrinus (r).
22. D. selenurus (r).

Faunule of zone 3 of section 1357 B, on north side of Ohio River.

[c, common.]

1. Stropheodonta demissa (c).
2. S. hemispherica (r).
3. Chonetes mucronatus (c).
4. Atrypa reticularis (c).
5. Spirifer acuminatus (c).
6. Proetus cf. crassimarginatus (c).

Faunule of zone 2 (Sellarsburg cement beds) of section 1357 C, at Louisville, Ky.

[a, abundant; c, common; r, rare.]

1. Stropheodonta demissa (r).
2. Chonetes yandellanus (a).
3. Leiorhynchus quadricostatum (c).
4. Atrypa reticularis (a).
5. Spirifer oweni (a).
6. S. segmentus (c).
7. S. subattenuatus (r).
8. Proetus sp. (r).

The only fossil found in the black shale (New Albany) at Louisville (1357 A3) was *Lingula spatulata.*

Near the mouth of Silver Creek, below the falls, *Schizobolus concentricus* occurs abundantly in the black shale (1357 A3).

The Rockford limestone (1357 A4) contains no fossils at its exposures near New Albany. This limestone appears to be absent south of the Ohio.

BROOKS, BULLITT COUNTY, KY.

A connected section of the rocks in the vicinity of Brooks station, about 15 miles south of Louisville, is made up of beds exposed at the three following localities: (A) Brooks, Bullitt County; (B) Button Mold Knob, three-fourths mile northeast of Brooks; (C) 1 mile west of Brooks. The general section is as follows:

Generalized section 1365, near Brooks, Ky.

	Feet.
C2. Massive sandstone	40 to 50
C1. Sandy shale and sandstone	50 to 75
B1. Blue clay shale	50 to 65
A3. Black shale (New Albany)	15 to 30
A2. Limestone (Devonian)	2 to 6
A1. Limestone and sandstone (Niagara)	15 to 20
	172 to 246

The black shale (A3) rests unconformably on the Devonian limestone in the vicinity of Brooks. In the bed of Brooks Run, between the railroad and the wagon road, the lowest strata of the black shale lie in shallow, irregularly eroded pockets in the limestone. In some of these a thin layer of reddish clay was observed between the limestone and the undisturbed black shale. The unconformity is illustrated in the accompanying figure.

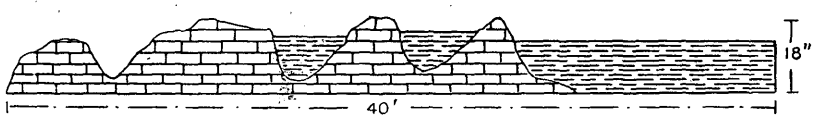


FIG. 1.—Section on Brooks Run, Bullitt County, Ky., showing unconformity between (black) New Albany shales and the Devonian (Jeffersonville) limestone.

One-half mile northeast of Brooks the shale (New Albany) has a drab color, and furnished the following faunule:

Faunule of zone 3 of general section 1365 A, near Brooks, Ky.

[c, common.]

1. Lingula spatulata (c).
2. Chonetes scitulus (c).
3. Leiorhynchus cf. quadricostatum (c).
4. Pleurotomaria sp. (c).

The upper argillaceous member of the Devonian (Sellarsburg beds), which is worked for cement at Louisville, is entirely wanting in this section. The Devonian limestone in the section represented by fig. 1 probably does not exceed 2 feet in thickness. Below it is the siliceous Niagara limestone (A1), which outcrops in the wagon road and contains the following species:

Faunule of zone 1 of general section 1365 A, near Brooks, Ky.

[c, common.]

1. Favosites niagarensis (c).
2. Halysites catenulatus (c).

The Devonian limestone in the bed of Brooks Run, between the railroad and wagon road, Brooks, Ky., afforded the following fossils:

Faunule of zone 2 of general section 1365 A, near Brooks, Ky.

[c, common; r, rare.]

1. Stropheodonta demissa (r).
2. S. (Leptostrophia) perplana (c).
3. Rhipidomella livia (r).
4. Pentamerella arata (r).
5. Camarotœchia sp.
6. Atrypa reticularis (c).
7. Spirifer fornacula (r).
8. S. varicosus (r).
9. Actinopteria sp.
10. Proetus crassimarginatus (c).
11. Phacops rana (r).

The blue clay shale (New Providence) at the base of Button Mold Knob contains the following species:

Faunule of zone 1 of general section 1365 B, near Brooks, Ky.

[a, abundant; r, rare.]

1. Zaphrentis sp. (r).
2. Amplexus sp. (r).
3. Crinoid stems (a).
4. Orthothetes crenistria (r).
5. Chonetes illinoisensis (r).
6. Rhipidomella oweni (a).
7. Spirifer suborbicularis (a).
8. Platyceras sp. (a).

The latest fauna of the section is obtained from the massive sandstone (Riverside) 1 mile west of Brooks station, Ky.

Faunule of zone 2 of general section 1365 C, near Brooks, Ky.

[c, common; r, rare.]

1. Fenestella sp. (c).
2. Discina sp. (r).
3. Orthothetes crenistria (r).
4. Derbya keokuk (c).
5. Productus burlingtonensis (c).
6. Camarotœchia sappho (c).
7. Syringothyris carteri (c).
8. Cypricardinia sp. (r).

HUBER, BULLITT COUNTY, KY.

The unconformity between the black shale and the underlying limestones is well shown in the section exposed in the railroad cut one-fourth mile south of Huber.

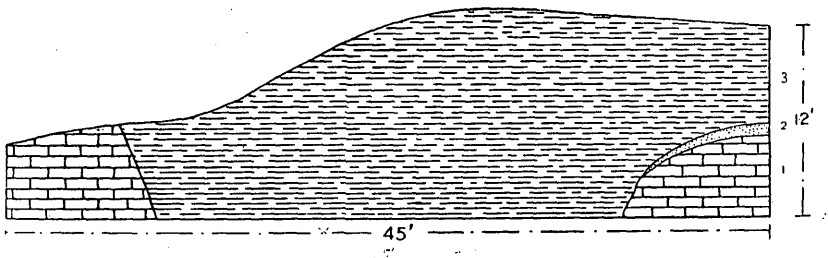


FIG. 2.—Section 1367 A, showing unconformity of the black shale and the Devonian limestone south of Huber, Ky. 1, Devonian limestone; 2, red clay; 3, black shale.

As shown in fig. 2, the shale on one side of the section is separated from the limestone by about 4 inches of red clay.

The limestone (Sellarsburg) directly under the black shale in the railroad cut, one-fourth mile south of Huber, contains the following species:

Faunule of zone 1 of section 1367 A, near Huber, Ky.

[a, abundant; c, common; r, rare.]

1. Orthis sp. (r).
2. Camarotœchia tethys (c).
3. Tropidoleptus carinatus (r).
4. Spirifer cf. davisi (r).
5. Reticularia fimbriata (r).
6. Spirifer segmentus (r).
7. S. varicosus (r).
8. Ambocœlia umbonata (a).
9. Athyris spiriferoides (r).
10. Platyceras sp. (r).

The Niagara limestone is exposed at the roadside one-half mile south of Huber station. Fossils are scarce in it, and only the following were obtained:

Faunule of zone 1 of section 1367 B, near Huber, Ky.

[c, common; r, rare.]

1. Halysites catenulatus (c).
2. Cladopora sp. (c).
3. Conchidium cf. littoni (r).
4. C. sp. (r).

CLERMONT, BULLITT COUNTY, KY.

The Niagara limestone is quarried extensively at Clermont. The section exposed at one of the quarries is as follows:

Section 1368 A, at Clermont, Ky.

	Feet.
4. Devonian limestone with crinoid stems	3
3. Siliceous and dolomitic limestone	15–20
2. Blue shale	6
1. Hard blue limestone	15

Only a single species, *Calymene niagarensis*, was obtained from the bed (A1) below the blue shale.

The rocks in the quarry appear to contain few fossils. The following-named species, however, were collected from a fine-grained sandstone (1368 B), which outcrops in a ravine about one-fourth mile southeast of the quarry, and which appears to be the equivalent of the zone 3 of the quarry (1368 A).

Faunule of section 1368 B, near Clermont, Ky.

[a, abundant; c, common; r, rare.]

1. Zaphrentis cf. stokesi (c).
2. Cyathophyllum sp. (r).
3. Anastrophia internascens (r).
4. Conchidium cf. nysius (r).
5. Pentamerus oblongus (a).
6. Pentamerella sp. (r).
7. Rhynchonella stricklandi (r).
8. Atrypa reticularis (c).
9. A. reticularis var. niagarensis (c).
10. Spirifer radiatus (r).
11. Meristina maria (c).
12. Conocardium sp. (r).

Five miles northeast of Clermont the blue clay shale of the "knob stone" has been extensively denuded of soil and vegetation by "washes" on the slope of Deerlick Knob, exposing the following section:

Section 1368 C, at Deerlick Knob, Bullitt County, Kentucky.

	Feet.
5. Blue clay shale	35
4. Thin-bedded crinoidal limestone	5
3. Black shale	15
2. Covered	15
1. Limestone	3
	73

Faunule of zone 5 of section 1368 C, at Deerlick Knob, Kentucky.

[a, abundant; c, common; r, rare.]

1. Zaphrentis dalei (a).
2. Chonetes illinoisensis (r).
3. Productus semireticulatus (c).
4. Dielasma cf. bovidens (r).
5. Spirifer marionensis (r).
6. S. mortonanus (c).
7. S. sp. (r).
8. Athyris lamellosa (a).

The blue-clay shales containing this faunule are similar in lithologic as well as faunal characters to the New Providence shale of southern Indiana, of which they are the southern continuation.

The thin limestone of this section, at the top of the black shale, is of particular interest because it occupies the same stratigraphic horizon as the Rockford limestone 30 miles to the northwest, while it carries the lower "knob" (New Providence shale) fauna, which is entirely unlike that of the Rockford limestone. The following species were obtained at Deerlick Knob, Ky.:

Faunule of zone 4 of section 1368 C, at Deerlick Knob, Kentucky.

1. Rhipidomella oweni (abundant).
2. Spirifer mortonanus (common).
3. S. suborbicularis (common).

NEW HAVEN, NELSON COUNTY, KY.

The Devonian limestone was not seen at New Haven and, if present there, is very thin. The following section is exposed just west of the town, on the bank of Rolling Fork:

Section 1371 A, at New Haven, Ky.

	Feet.
3. Black shale	5
2. Covered	4
1. Dolomitic limestone	7

The dolomitic limestone, 1 of the above section, furnished the following Niagara species:

Faunule of zone 1 of section 1371 A, near New Haven, Kentucky.

1. Calymene niagarensis (common).
2. Dalmanites verrucosus (rare).

About 5 miles south of New Haven the following section is exposed along the pike at Muldrows Hill:

Section 1371 B, at Muldrows Hill, Kentucky.

	Feet.
9. Covered	10
8. Shaly limestone and shale	20
7. Shale	3–5
6. Limestone	20
5. Sandstone	9
4. Limestone	18
3. Bluish sandstone weathering shaly	40
2. Blue shaly sandstone	15
1. Shaly sandstone and shale	15

The above section shows the interpolation of the Harrodsburg ("Lower Carboniferous") limestone beds in the Knobstone sandstone.

The following section shows a similar interstratification of the limestone and Knobstone sandstone, 2 miles southwest of New Haven:

Section 1371 C, 2 miles south of New Haven, Ky.

	Ft.	In.
7. Shaly sandstone	8	0
6. Limestone	1	8
5. Gray sandy shale	10	0
4. Limestone and shale	18	0
3. Covered (mostly shale)	10	0
2. Iron-ore concretions	0	4
1. Black shale	10	0

It may be noted that the limestone at the top of the black shale in the Deerlick section (1368 C4) is represented in the above section only by a band of ferruginous concretions (1371 C2). No fossils were seen in the blue clay shale above the black shale except crinoid stems.

RILEY, MARION COUNTY, KY.

The Ordovician limestone outcrops about 100 yards northwest of Riley station with a dip of 10° to 15° southwest. The black shale is exposed in the cut at the station. A short distance northwest of the cut the shale rests unconformably on rocks which are probably of Niagara age. No fossils were found in them. The Ordovician outcrops northwest of Riley station (section 1372 A) afforded the following fossils:

Faunule of section 1372 A, northwest of Riley station.

1. Platystrophia crassa (rare).
2. P. lynx (common).
3. Murchisonia sp. (common).

In a sandy shale, just south of Riley station (section 1372 B), the following Knobstone faunule was collected:

Faunule of section 1372 B, south of Riley station, Kentucky.

[a, abundant; c, common; r, rare.]

1. Orthothetes crenistria (c).
2. Chonetes illinoisensis (a).
3. Productella shumardana (a).
4. Productus burlingtonensis (c).
5. P. punctatus (r).
6. P. semireticulatus (c).
7. Schizophoria sp. (r).
8. Camarotœchia sappho (r).
9. Spiriferina subelliptica (c).
10. Spirifer marionensis (r).
11. S. sp. (r).
12. Syringothyris texta (r).
13. Palæoneilo bedfordensis (r).
14. Macrodon cf. newarkensis (r).
15. Streblopteria sp. (r).
16. Cypricardinia sp. (c).

PARKSVILLE, BOYLE COUNTY, KY.

About three-fourths of a mile west of Parksville the black shale rests directly on the Ordovician, as shown in the accompanying section:

Section 1373 A, at Parksville, Ky.

	Feet.
2. Black shale	6
1. Soft blue shaly sandstone	4

The following species were collected from the shaly sandstone of the above section:

Faunule of zone 1 of section 1373 A; near Parksville, Ky.

1. Hebertella cf. occidentalis (rare).
2. Platystrophia laticosta (common).
3. P. lynx (common).

The black shale about Parksville is about 25 feet thick. The blue clay shale above it has its usual appearance. The Knobstone Hills, just south of the railroad, are about 150 feet high and have an abundance of loose limestone fragments on their summits. No beds of the limestone were seen in place.

At an old quarry in the "Knobstone" sandstone (section 1373 B), 1½ miles west of Parksville, the following species were collected:

Faunule of section 1373 B, near Parksville, Ky.

[c, common; r, rare.]

1. Orthothetes crenistria (c).
2. Productella cf. shumardana (r).
3. Productus alternatus (r).
4. P. semireticulatus (r).
5. Camarotœchia sp. (r).
6. Dielasma cf. formosa (c).
7. Spirifer keokuk (c).
8. S. lateralis (r).
9. Reticularia pseudolineata (c).
10. Eumetria marcyi (r).
11. Leiopteria sp. (r).
12. Platyceras bodensis (r).

JUNCTION CITY, BOYLE COUNTY, KY.

The black shale outcrops at a number of places in the vicinity of Junction City. It extends below drainage, so that the underlying beds were not seen. The following section indicates the stratigraphic relations:

Section 1374 A, at Lone Knob, near Junction City, Ky.

	Feet.
3. Shaly sandstone	60
2. Blue clay shale	80
1. Black shale	15

CRAB ORCHARD, LINCOLN COUNTY, KY.

The Devonian limestone appears to be entirely absent in the vicinity of Crab Orchard. The following connected section includes the lowest beds observed in the vicinity of the springs and those outcropping in the knobs southwest of town:

Section 1375 A, near Crab Orchard, Ky.

	Feet.
5. Shaly sandstone ("Knobstone"	50
4. Shaly crinoidal limestone	3–4
3. Shaly sandstone and clay shale (partly covered)	100
2. Black shale	35
1. Buff to brownish fine-grained sandstone	10

No fossils were found in the fine-grained sandstone below the black shale.

The shaly sandstone (zone 5 of section 1375 A), 2 miles southwest of Crab Orchard, furnished the following faunule:

Faunule of zone 5 of section 1375 A, near Crab Orchard, Ky.

[c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Chonetes illinoisensis (c).
3. Productus sp. (r).
4. Camarotœchia cf. contracta (r).
5. Spiriferina subelliptica (c).
6. Spirifer mortonanus (c).
7. S. suborbicularis (c).
8. Reticularia pseudolineata (r).
9. Syringothyris texta (c).
10. Ptychospira cf. sexplicata (r).
11. Athyris lamellosa (c).
12. Sphenotus sp. (r).
13. Edmondia sp. nov. (r).
14. Conocardium pulchellum (c).
15. Cypricardinia sp. (c).
16. Loxonema sp. nov. (r).
17. Platyceras cf. herzeri (r).
18. P. sp. (c).
19. Proetus auriculatus (r).
20. Phaëthonides sp. (r).

SECTIONS IN VIRGINIA AND WEST VIRGINIA.

By E. M. KINDLE.

The faunas from Virginia and West Virginia were collected in part by H. S. Williams in 1895, and in part by E. M. Kindle in 1898.

The Virginia and West Virginia localities examined furnished faunules from the following localities, viz:

Sections in Virginia and West Virginia.

1376. Bigstone Gap, Wise County, Va.
- A. East Fork of Powell River, above flouring mill.
- B. Cuttings of Southern Railway, northeast of Bigstone Gap.
- C. On bank of Powell River, east side village at woolen mill.
- D. South bank of river.
- E. Loose in fields and talus heaps of rock exposure at Little Stone Gap.

1377 A. Big Moccasin Gap, Va., between the railroad switch at the gap and the limestone southeast of Doctor Wallace's residence.

1379. Hicksville, Bland County, Va.
- A1. About 1½ miles above Hicksville in small ravine on Mr. Hornbarger's land.
- A2. A few hundred yards east of 1379 A1 in bed of Kimberling Creek.
- A3. One-half mile north of Hicksville.
- A4. One mile east of Hicksville, near summit of Brushy Mountain.
- B. On the Bluefield and Bland road, 300 yards southeast of summit of Brushy Mountain, and about 2 miles southwest of A4.
- C. West of Point Pleasant, near top of Brushy Mountain.
- X. On the Bluefield and Bland road, about 1¼ miles south of Rocky Gap post-office.

1380. White Sulphur Springs, W. Va.
- A. Hotel grounds.
- B. West end of tunnel and cuts along railroad southeast of White Sulphur Springs.
- C. West end of long cut 1½ miles southeast of White Sulphur Springs.
- D. Side of railroad three-fourths mile west of White Sulphur Springs.
- E. Wagon road 1¼ miles west of White Sulphur Springs.
- F. One-half mile east of Howard station.

1381 A. Caldwell, W. Va.

1382. Covington, Va.
- A. East of Caldwell, W. Va.
- B. One-half mile southeast of blast furnace, on north bank of Jackson River.
- C. West bank of Jackson River, one-fourth mile south of Chesapeake and Ohio Railway bridge at Covington.

1383 A. Northwest of Hot Springs, Va., along the Chesapeake and Ohio Railway.

1384 A. Near the Chesapeake and Ohio Railway bridge west of Clifton Forge, Va.

BIGSTONE GAP, WISE COUNTY, VA.

The Hancock limestone and the Grainger shale[a] are well exposed just northeast of Bigstone Gap, between the East Fork of Powell River and the Virginia and Southwestern Railway. On the East Fork of Powell River, just above the flouring mill, the Hancock limestone outcrops with a strike of S. 80° W., and a dip of 60° N. Above the limestone are about 50 feet of coarse sandstone.

[a] Estillville sheet, Geol. Atlas U. S.

Section 1376 A, on East Fork of Powell River, above flouring mill.

	Feet.
2. Coarse sandstone ("Oriskany")	50
1. Hancock limestone, top of	10

Faunule of zone 1 of section 1376 A, on East Fork of Powell River.

[c, common; r, rare.]

1. Stropheodonta beckii (r).
2. S. cf. planulata (r).
3. Strophonella cavumbona (r).
4. Leptæna rhomboidalis (c).
5. Rhipidomella sp. (r).
6. Gypidula pseudogaleata (r).
7. Rhynchonella altiplicata (c).
8. Rensselæria mutabilis (r).
9. Cyrtina cf. dalmani (r).
10. Nucleospira sp. (r).
11. Meristella lævis (c).
12. M. subquadrata (r).
13. Platyceras sp. (r).
14. Tentaculites elongatus (r).

Faunule of zone 2 of section 1376 A, on East Fork of Powell River.

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Favosites sp. (r).
3. Strophonella cavumbona (r).
4. Leptæna rhomboidalis (c).
5. Orthothetes woolworthanus (r).
6. Dalmanella cf. planiconvexa (r).
7. Rhipidomella oblata (c).
8. Camarotœchia ventricosa (a).
9. Cyrtina cf. dalmani (c).
10. Spirifer cyclopterus (a).
11. Meristella lævis (c).
12. Platyceras pyramidatum (r).
13. Tentaculites elongatus (r).
14. Proetus protuberans (r).

At the side of the Southern Railway, northeast of Bigstone Gap, the sandstone lies upon the limestone, and across the river to the north the black shale appears, given in the section below. The succession was clear, but the exact thickness of the beds was not evident.

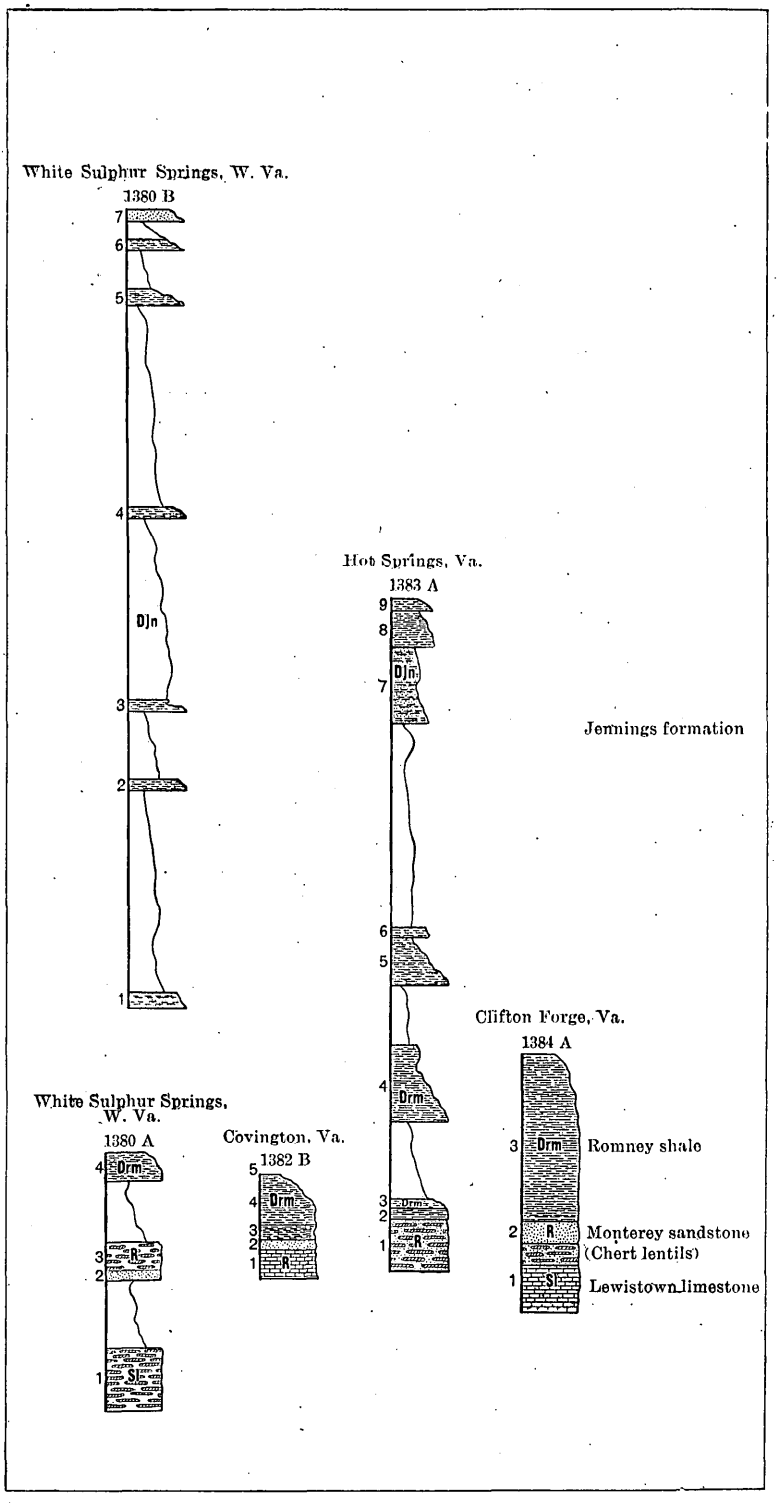
Section 1376 B, on Southern Railway, near Bigstone Gap.

3. Black shale.
2. Sandy and cherty beds ("Oriskany").
1. Hancock limestone.

Faunule of zone 2 of section 1376 B, on Southern Railway, near Bigstone Gap.

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Aulopora sp. (r).
3. Aspidocrinus scutelliformis (r).
4. Stictopora sp. (r).
5. Polypora sp. (r).
6. Roemerella cf. grandis (r).
7. Stropheodonta lincklæni (r).
8. S. magnifica (c).
9. S. beckii (c).
10. Strophonella cavumbona (c).
11. Leptæna rhomboidalis (a).
12. Orthothetes woolworthanus (c).
13. Dalmanella cf. planiconvexa (r).
14. Rhipidomella oblata (a).
15. Gypidula pseudogaleata (r).
16. Rhynchotrema formosum (r).
17. Camarotœchia ventricosa (a).
18. Uncinulus campbellanus (r).
19. Rhynchonella acutiplicata (c).
20. Rensselæria mutabilis (r).
21. R. sp. (r).
22. Atrypa reticularis (r).
23. Cyrtina dalmani (c).
24. Spirifer cyclopterus (a).
25. S. sp. (r).
26. Meristella cf. bella (r).
27. M. subquadrata (c).
28. M. sp. (r).
29. Avicula communis (r).
30. Loxonema sp. (r).
31. Holopea antiqua (r).
32. Proetus sp. (r).
33. Homalonotus sp. (r).
34. Phacops cf. cristata (r).
35. P. logani (c).



SECTIONS IN VIRGINIA AND WEST VIRGINIA.

In the bed of the ravine just north of the sand and cherty beds (1376 B2), the black Chattanooga shale (1376 B3) is exposed. It has a deep black color and contains an abundant fauna composed of *Lingula ligea* and *Schizobolus concentricus*.

The sandy beds of the Hancock limestone are well exposed about the iron furnace, and just north of the subterranean mouth of Wild Cat Creek. Collections from this locality were lost in transit.

On bank of Powell River by the woolen mill east of the village a section (1376 C) yielded the following fossils:

Faunule of section 1376 C, on Powell River.

[c, common; r, rare.]

1. Calceola cf. plicata (r).
2. Leptæna rhomboidalis (r).
3. Rhipidomella oblata (r).
4. Gypidula pseudogaleata (c).
5. Camarotœchia ventricosa (c).
6. Rhynchonella acutiplicata (r).
7. Spirifer cumberlandiæ (c).
8. S. cyclopterus (r).
9. Reticularia cf. fimbriata (r).
10. Meristella subquadrata (c).
11. Phacops cristata (r).
12. Dalmanites cf. anchiops (r).
13. D. pleuroptyx (r).

Along the river bank on the south side Mr. Williams collected from the reddish sandstone beds (1376 D), immediately below the Mississippian ("Lower Carboniferous") limestone, a fossil sponge which appears to be identical with the species described from the Waverly of Pennsylvania as *Ectenodictya inflexa*.

From rocks in the fields and in place at Little Stone Gap (1376 E) Mr. Williams collected species representing the fauna from the coarse sandstone beds underlying the black shale.

Faunule of section 1376 E, at Little Stone Gap, Va.

[c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Cyathophyllum sp. (r).
3. Cystiphyllum sp. (r).
4. Favosites sp. (r).
5. Cladopora sp. (r).
6. Gypidula pseudogaleata (c).
7. Atrypa reticularis (r).
8. Spirifer cyclopterus (r).
9. S. perlamellosus var. (r).
10. Meristella subquadrata (c).
11. Cyrtolites sp. (r).
12. Platyceras cf. gebhardi (c).
13. Tentaculites sp. (r).
14. Dalmanites cf. pleuroptyx (r).

BIG MOCCASIN GAP, VA.

At Big Moccasin Gap the rocks dip from 30° to 40° SE. The strike is about S. 20° W., or approximately the direction of Clinch Mountain. The following section is based on the nearly continuous outcrops seen between the railroad switch at Big Moccasin Gap and the limestone southeast of Doctor Wallace's residence.

Section 1377 A, at Big Moccasin Gap, Va.

	Feet.
7. Limestone and shale (Carboniferous)	
6. Soft yellowish clay and crumbling sandstone	100
5. Hard, drab-colored sandy shale and sandstone	40
4. Conglomerate band near top of 3′	60
3. Hard, bluish-gray to drab sandy shale	
2. Black shale, varying to gray, and much crushed and folded	150
1. Tough quartzitic fine-grained sandstone	75

In the Estillville folio, 2 is called the Chattanooga black shale, and 3 to 6 are assigned to the Grainger shale. The lowest fauna obtained from the section is from the lower part of 3, about 20 feet above the black shale.

Faunule of zone 3 of section 1377 A, at Big Moccasin Gap, Virginia.

[c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Crinoid stems (c).
3. Fenestella sp. (r).
4. Lingula gannensis (r).
5. Orbiculoidea sp. (c).
6. Chonetes sp. (r).
7. Productus cora var. (r).
8. P. cf. semireticulatus (r).
9. P. cf. wortheni (c).
10. P. sp. (r).
11. Camarotœchia sp. (r).
12. Spirifer cf. marionensis (c).
13. Reticularia pseudolineata (c).
14. Syringothyris carteri (r).
15. Athyris lamellosa (c).
16. Conularia sp. (r).

About 40 feet above the last zone a rich fauna occurs in the thin bands of ferruginous conglomerate which outcrop at the roadside nearly opposite the residence of Doctor Wallace. This is unquestionably a Knobstone or Waverly fauna. Some of the species are identical with those from the southern Indiana Knobstone. The following species were obtained:

Faunule of zone 4 of section 1377 A, at Big Moccasin Gap, Virginia.

[a, abundant; c, common; r, rare.]

1. Chonetes sp. (a).
2. Camarophoria sp.
3. Dielasma sp. nov. (c).
4. Spiriferina cf. solidirostris (a).
5. Spirifer sp. (c).
6. Reticularia pseudolineata (r).
7. Syringothyris sp. (c).
8. Glossites sp. (r).
9. Spathella sp. (r).
10. Edmondia sp. (r).
11. Nucula sp. (r).
12. Palæoneilo perplana (a).
13. P. sulcatina (a).
14. P. sp.
15. Nuculana spatulata (r).
16. Leptodesma sp. (r).
17. Schizodus sp. (r).
18. Bellerophon sp. (a).
19. B. sp. (a).
20. Pleurotomaria stulta (r).
21. P. sp. (a).
22. Loxonema sp. (c).
23. Platyceras sp. (r).
24. Orthoceras sp. (c).
25. O. sp. (c).
26. Prolecanites greeni (r).
27. Phaëthonides sp. (r).

About 30 or 40 feet above the last zone, the following species were collected from a shaly dark-gray sandstone, about 100 yards southeast of Doctor Wallace's house:

Faunule of zone 5 of section 1377 A, near Big Moccasin Gap, Virginia.

[c, common; r, rare.]

1. Lepidodendron sp. (r).
2. Crinoid stems (r).
3. Lingulodiscina newberryi (r).
4. Productus sp. (c).
5. Camarotœchia sp. (r).
6. Spirifer keokuk (c).
7. Sphenotus flavius (c).
8. Edmondia sp. (r).
9. Palæoneilo bedfordensis (c).
10. Macrodon sp. (r).
11. Pinna sp. (r).
12. Schizodus sp. (r).
13. Actinopteria sp. (c).
14. Crenipecten sp. (r).
15. Modiomorpha sp. (r).
16. Bellerophon sp. (r).
17. Conularia newberryi (r).

The soft yellow arenaceous sandstone (6) between the last station and the Mississippian ("Lower Carboniferous") limestone afforded the following fossils: *Productus cora*, *Camarotœchia contracta*. Both these forms are common.

BLAND COUNTY, VA.

In Bland County collections were made in the valleys of Wolf and Kimberling creeks and at the summit of Brushy Mountain, east of Hicksville post-office.

Wolf and Kimberling creeks have cut their valleys into the easily eroded black shale (the Romney shale of the Pocahontas folio), which is estimated by Campbell[a] to have a thickness of from 400 to 600 feet. This shale dips sharply SE. and has the deep black color and finely laminated appearance generally characteristic of the black shale. Toward the top it merges into a hard, sandy, greenish-gray shale. The change is not abrupt, but beyond the limits of the 20 or 30 feet of passage beds the appearance and composition of the two formations are quite distinct. Campbell[b] regards the rocks in this region, between the Romney shale and the base of the Pennsylvanian ("Coal Measures,") as a lithologic unit, and has given them the name of Kimberling shale.

While it is difficult to separate the upper from the lower portion of this series on lithologic grounds, the fossils show that two distinct time periods are represented. The Mississippian ("Lower Carboniferous") limestone is absent here, and the transition from the Kimberling shale to the Pennsylvanian is made with such imperceptible changes in the appearance of the rocks that the limits of the two are difficult to sharply define.

Along the southeastern foot of Round Mountain a heavy bed of dark-gray chert, with occasional interstratified thin beds of greenish or yellowish sandstone lies just below the Romney shale. This is a

[a] Campbell, M. R., Description of Pocahontas district: Geol. Atlas U. S., folio 26, U. S. Geol. Survey, 1896.

[b] Ibid.

portion of the Giles formation of Campbell. The chert bed is nearly everywhere hidden by the loose fragments produced by weathering, so that its thickness was not ascertained.

General section 1379, near Hicksville, Va.

C. Thin-bedded sandstone.
B. Shaly sandstone. } Kimberling shale.
A4. Shaly sandstone.
A3. Dark-colored sandy shale, about 75 feet above A2.
A2. Black shale (Romney shale).
A1. Sandstone and chert (Giles formation).

About 1½ miles above Hicksville, in a small ravine on Mr. Hornbarger's land, the following fossils were obtained from a few inches of sandstone (1379 A1) interbedded with chert.

Faunule of zone 1 of section 1379 A, near Hicksville, Va.

[a, abundant; c, common; r, rare.]

1. Pholidops cf. arenaria (c).
2. Stropheodonta sp. (r).
3. Leptæna rhomboidalis (r).
4. Chonetes sp. nov. (r).
5. Anoplia nucleata (c).
6. Orthis sp. (r).
7. Amphigenia cf. elongata (r).
8. Rhynchonella sp. (r).
9. Spirifer cumberlandiæ (a).
10. S. sp. (c).
11. Ambocœlia sp. (r).
12. Nucleospira sp. (r).
13. Anoplotheca cf. dichotoma (r).
14. Platyostoma ventricosum (r).
15. Tentaculites elongatus (r).

A few hundred yards east of 1379 A1, in the bed of Kimberling Creek, *Schizobolus truncatus* is common in the Romney or black shale (1379 A2). The same species is also found in the black shale in bank of creek, one-half mile south of Hicksville, Va. The drab or greenish sandy shale which follows the Romney shale appears to be barren of fossils at most localities.

About one-half mile north of Hicksville (1379 A3) a few specimens of *Palæoneilo brevis* and *Goniatites* sp. were found just east of the ford and about half way up the face of the cliff. The horizon of this station is probably 100 feet above the top of the typical Romney shale.

On Brushy Mountain, east of Hicksville, no fossils were found above station 1379 A3, until within 100 feet of the summit (1379 A4), where a rich Chemung fauna was discovered in the Kimberling shale.

Faunule of zone 4 of section 1379 A, near the summit of Brushy Mountain, Virginia.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea sp. (r).
2. Chonetes scitulus (a).
3. Productella sp. (r).
4. Camarotœchia contracta (a).
5. C. sappho (r).
6. Spirifer disjunctus (c).
7. Grammysia subarcuata (c).
8. Sphenotus contractus (r).
9. Leptodesma matheri (r).
10. L. potens (a).
11. L. potens var. juvene (r).
12. Mytilarca chemungensis (c).
13. Nyassa cf. arguta (r).
14. Modiomorpha subalata var. chemungensis.
15. Goniophora chemungensis (r).
16. Euomphalus sp. (r).

The Chemung fauna may be found at or near the summit of Brushy Mountain at most localities in Bland County. About 2 miles southwest of the last station and 300 yards southeast of the summit of Brushy Mountain, on the Bluefield and Bland road (1379 B), the following species were found:

Faunule of section 1379 B, on Brushy Mountain, Virginia.

[a, abundant; c, common; r, rare.]

1. Productella hirsuta (c).
2. Dalmanella tenuilineata (r).
3. Camarotœchia cf. contracta (c).
4. C. duplicata (a).
5. Amboccelia umbonata (c).
6. Grammysia subarcuata (r).
7. Edmondia cf. philipi (r).
8. Leptodesma cf. potens (r).
9. Leptodesma sp. (r).
10. Mytilarca chemungensis (c).
11. Nyassa cf. arguta (r).
12. Modiomorpha subalata var. chemungensis (r).
13. M. sp. (r).
14. Orthoceras sp. (r).

Near the top of Brushy Mountain west of Point Pleasant (1379 C) the following species occur:

Faunule of section 1379 C, on Brushy Mountain, Virginia.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea sp. (r).
2. Chonetes setigerus (a).
3. Productella lachrymosa var. stigmata (c).
4. Camarotœchia contracta (c).
5. C. duplicata (r).
6. Spirifer disjunctus (r).
7. Grammysia cf. bisulcata (r).
8. Sphenotus sp. (r).
9. Leptodesma potens (r).
10. L. potens var. juvene (r).
11. Mytilarca regularis (r).
12. Aviculopecten sp. (r).

About 1¼ miles south of Rockygap post-office, on the Bluefield-Bland road, the following fossils were collected from some detached masses of coarse sandstone (1379 X). The stratigraphic position of this sandstone was not certainly ascertained, but it appears to belong to the Giles formation:

Faunule of section 1379 X, near Rockygap, Va.

1. Aspidocrinus scutelliformis (abundant).
2. Spirifer cyclopterus (rare).
3. Meristella sp.

WHITE SULPHUR SPRINGS, W. VA.

In the vicinity of White Sulphur Springs the channel of Howards Creek follows approximately the axis of an anticline. The lowest beds exposed here are the black and gray cherts, which outcrop along the bank of this stream at the northwest side of the White Sulphur Springs Hotel grounds. From this point the dip of the beds is toward the southeast. From White Sulphur Springs station to Tuckahoe the

Chesapeake and Ohio Railway crosses the strike of the beds nearly at right angles. The numerous cuts along this section of the road, together with the outcrops on the hotel grounds, afford a section from the black cherts nearly through the shales and sandstones of the Chemung. The following section includes all the outcrops observed on the west side of the White Sulphur Springs Hotel grounds:

Section 1380 A, on White Sulphur Springs Hotel grounds, West Virginia.

	Feet.
4. Black shale ("Romney")	30
Concealed	30
3. Gray chert	25
2. Coarse sandstone ("Oriskany")	6
Concealed	60
1. Black chert	50
	201

The chert (1) in this section appears to be entirely barren of fossils. The sandstone (2) in the rear of Alabama row, White Sulphur Springs Hotel, contains the following species:

Faunule of zone 2 of section 1380 A, at White Sulphur Springs Hotel, West Virginia.

[a, abundant; c, common; r, rare.]

1. Crinoid plate.
2. Hipparionyx proximus (r).
3. Orthis sp. (c).
4. Dalmanella cf. planiconvexa (c).
5. Rhipidomella musculosa (a).
6. Eatonia peculiaris (c).
7. E. pumila (c).
8. Rhynchonella oblata (r).
9. Rensselæria cf. marylandica (r).
10. R. ovoides (a).
11. Beachia cf. suessana (c).
12. Leptocœlia sp. (c).
13. Spirifer arenosus (a).
14. S. murchisoni (c).
15. S. sp. (r).
16. Meristella lata (r).
17. Platyceras cf. gebhardi (r).
18. P. ventricosum (r).

No fossils were discovered in the gray chert (3). On the hotel grounds, at the east end of Baltimore row, numerous specimens of *Schizobolus truncatus* were found in the black ("Romney") shale (4).

The black carbonaceous shale containing *Schizobolus truncatus* changes gradually to a dark-gray or blackish sandy shale (Jennings), containing the fauna listed below, which is seen at the west end of tunnel, White Sulphur Springs (1380 B):

Section 1380 B, along railroad from west end of tunnel to long cut 1¼ miles southeast of White Sulphur Springs, W. Va.

	Feet.
7. Greenish sandstone and shale	50
6. Greenish shale	200
5. Shale, northwest end of cut below tool house	100
4. Green to gray shale	140
3. Greenish shale	60
2. Greenish shale	160
1. Sandy shale at west end of tunnel	150

Faunule of zone 1 of section 1380 B, at west end of tunnel, White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Paracardium doris (r).
2. Buchiola speciosa (a).
3. Palæoneilo brevis (r).
4. Orthoceras bebryx var. cayuga (r).
5. Parodiceras discoideum (c).
6. Goniatites sp. (c).

The beds containing this Nunda (*Buchiola speciosa*) fauna are probably 150 feet thick. They are followed by 100 feet or more of soft greenish clay shale in which no fossils were found.

The following zones are exposed in the cuts along the railroad southeast of White Sulphur Springs. About 150 feet above the last zone the greenish shale, 1380 B2, contains the following species:

Faunule of zone 2 of section 1380 B, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea neglecta (c).
2. Leiorhynchus laura (a).
3. Delthyris mesicostalis (r).
4. Amboccelia gregaria (a).

About 60 feet above the last zone is greenish shale containing the following species:

Faunule of zone 3 of section 1380 B, near White Sulphur Spring, W. Va.

[a, abundant; c, common; r, rare.]

1. Craniella cf. hamiltoniæ (r).
2. Stropheodonta (Douvillina) mucronata.[a] (a).
3. Orthothetes chemungensis (r).
4. Productella cf. subalata (r).
5. P. sp. (r).
6. Dalmanella tioga (a).
7. Camarotœchia sappho (c).
8. C. sp. (r).
9. Leiorhynchus laura (a).
10. Delthyris mesicostalis (c).
11. Amboccelia gregaria (a).
12. Edmondia cf. rhomboidea (r).
13. Palæoneilo sp. (r).
14. Mytilarca chemungensis (r).
15. Actinopteria boydi (c).
16. Aviculopecten sp. (r).
17. Lyriopecten cf. tricostatus (r).

About 140 feet above 1380 B3 is a gray to greenish shale which contains the following fossils:

[a] It is important to notice that the species described by Hall in the fourth volume of Paleontology of New York (1867, p. 110, pl. 19, figs. 1-5) under the name *Strophodonta cayuta* n. s., and afterwards described generally in literature under that name, was described by Conrad in 1842 (Jour. Acad. Nat. Sci., Philadelphia, viii, p. 257, pl. 14, fig. 10) under the name *Strophomena mucronata*, and referred to the proper fauna (Chemung) to which it belongs and cited from a typical Chemung locality, Chemung Narrows, in southern New York. The species described by Hall in 1867 under the name *Strophodonta mucronata* (see p. 111, pl. 15, figs. 13, 14) and cited as the same as Conrad's species is actually distinct specifically and at least subgenerically. It belongs to the subgenus *Leptostrophia* of Hall and Clarke, and was previously correctly figured, but not described, by Vanuxem in 1842 (Geol. New York Rept. Third Dist., 1842, p. 174, fig. 1) under Phillip's name *Strophomena interstrialis*. As Phillip's species is also subgenerically distinct from it, the specific name *interstrialis* is available in the combination *Leptostrophia interstrialis* Vanuxem. Phillip's species would be *Douvillina interstrialis*. *Stropheodonta* (*Leptostrophia*) *interstrialis* Vanuxem is abundant in the Ithaca formation, and, though it may occur in the Chemung, is there extremely rare. On the other hand, *Stropheodonta* (*Douvillina*) *mucronata* Conrad does not, so far as thorough examination has revealed, occur until the Chemung epoch, and is a diagnostic Chemung species.—H. S. W.

Faunule of zone 4 of section 1380 B, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Lingula cf. ligea (r).
3. Stropheodonta (Douvillina) mucronata (c).
4. S. demissa (r).
5. Orthothetes cf. chemungensis (c).
6. Schizophoria striatula (r).
7. Dalmanella tioga[a] (c).
8. Atrypa hystrix (r)
9. A. reticularis (a).
10. A. spinosa (a).
11. Cyrtina hamiltonensis (c).
12. Spirifer disjunctus (c).
13. Actinopteria perstrialis (r).
14. A. cf. eta (r).
15. Pterinea (Vertumnia) reversa (c).
16. Pterinopecten sp. (r).

At the northwest end of cut below tool house, near White Sulphur Springs, with the following faunule, was found:

Faunule of zone 5 of section 1380 B, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (a).
2. Strophonella cælata (r).
3. Productella hirsuta (a).
4. Schizophoria striatula (c).
5. Leiorhynchus laura (r).
6. Atrypa spinosa (r).
7. Cyrtina hamiltonensis (r).
8. Spirifer disjunctus (a).
9. Ambocœlia gregaria (c).
10. Phthonia sp. (r).
11. Palæoneilo bisulcata (a).
12. P. filosa (r).
13. P. plana (r).
14. Leptodesma lichas (c).
15. Lyriopecten tricostatus (r).
16. Cypricardella sp. (r).

In cuts just north of tool house, probably 200 feet above B4, greenish shales (B6) yielded the following faunule:

Faunule of zone 6 of section 1380 B, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea sp. (r).
2. Stropheodonta (Douvillina) mucronata (c).
3. Productella hirsuta (a).
4. Dalmanella tenuilineata (c).
5. Atrypa spinosa (c).
6. Cyrtina hamiltonensis (r).
7. Spirifer disjunctus (a).
8. Ambocœlia gregaria (a).
9. Spathella sp. (r).
10. Edmondia philipi (r).
11. Palæoneilo bisulcata (r).
12. P. filosa (r).
13. Macrodon cf. chemungensis (r).
14. Leptodesma complanatum (r).
15. L. lichas (r).
16. L. protextum (r).
17. Actinopteria sp. (r).
18. Aviculopecten sp. (r).

[a] The species described by Hall in 1843 as *Orthis carinata* (Geol. New York, Rept. Fourth Dist., p. 267, fig. 1) and the species described by the same author under the name *Orthis interlineata* (non-Sowerby) and afterwards more fully described as *Orthis tioga* (Pal. New York, IV, 1867, p. 59, pl. 8, figs. 20-29) both belong to the genus *Dalmanella* Hall and Clarke (Pal. New York, VIII, Pt. I, 1892, pp. 205, 223), and do not belong to the genus *Schizophoria* King, to which Hall and Clarke referred it in 1892 (Pal. New York, VIII, Pt. I, 1892, pp. 213, 226, pl. 6, fig. 22, and pp. 212, 226, pl. 6, figs. 17, 18). Mr. Schuchert, in quoting the species (Bull. U. S. Geol. Survey No. 87, 1897, pp. 373, 375) has evidently overlooked this fact. The oversight may have arisen from a confusion of the valves. The carinated valve of *Dalmanella* is the pedicle valve, while the convex valve of *Schizophoria* is the brachial. Examination of the muscular scars will at once reveal the difference in the field. The Schizophorias are common below the Chemung, but they are rare in the Chemung until the upper part is reached, while the Dalmanellas are among the first forms to appear at the incoming of the Chemung fauna, and they are conspicuous representatives of the Chemung fauna.—H. S. W.

Greenish sandstone and shale (1380 B7) opposite the milepost contained the following species:

Faunule of zone 7 of section 1380 B, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (c).
2. Productella lachrymosa (a).
3. Dalmanella tenuilineata (r).
4. Schizophoria striatula (c).
5. Camarotœchia contracta (c).
6. Leiorhynchus laura (r).
7. Spirifer disjunctus (a).
8. Delthyris mesicostalis (a).

Near the milepost the road crosses the axis of a syncline, so that beyond this point the beds reverse their dip. This makes it impossible to indicate with precision the stratigraphic relation of the stations below and those already given.

In west end of long cut (1380 B), 1¼ miles southeast of White Sulphur Springs, is the following section:

Section 1380 C, along railroad, 1¼ miles southeast of White Sulphur Springs, the rocks dipping westward.

3. Loose specimens along track, 1½ miles beyond White Sulphur Springs.
2. Dark bluish-gray sandstone at east end of long cut.
1. Dark, sandy shales at west end of cut.

The exact relation, in thickness, of these beds to each other was not ascertained. The dark sandy shales (1) are about 60 feet thick and dip W. 25°. They contain the following faunule:

Faunule of zone 1 of section 1380 C, near White Sulphur Springs, W. Va.

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (a).
2. S. demissa (r).
3. Chonetes scitulus (a).
4. Productella cf. spinulicostata (c).
5. Dalmanella tioga (r).
6. Leiorhynchus mesicostale (c).
7. Atrypa spinosa (r).
8. Grammysia sp. (r).
9. Edmondia subovata (r).
10. E. transversa (r).
11. Buchiola speciosa (r).
12. Palæoneilo brevis (a).
13. P. constricta (r).
14. P. filosa (r).
15. P. sp. (r).
16. Leda diversa (r).
17. Macrodon sp. (r).
18. Leptodesma sp. (r).
19. Mytilarca chemungensis (r).
20. Aviculopecten sp. (r).
21. Crenipecten sp. (c).
22. Pleurotomaria sp. (r).
23. Coleolus sp.
24. Goniatites sp. (r).
25. Echinocaris sp. (r).

At the east end of long cut mentioned above is a dark, bluish-gray, shaly sandstone (1380 C2), which yielded the following faunule:

Faunule of zone 2 of section 1380 C, near White Sulphur Springs, W. Va.

[c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (r).
2. S. demissa (c).
3. Chonetes scitulus (c).
4. Productella hirsuta (r).
5. Atrypa reticularis (r).
6. A. spinosa (a).
7. Spirifer disjunctus (r).
8. Sphenotus undatus (r).
9. Palæoneilo brevis (r).
10. Pterinopecten sp. (r).

Loose specimens on the southwest side of the Chesapeake and Ohio Railway track, 1½ miles southeast of White Sulphur Springs, furnished the following species:

Faunule of zone 3 of section 1380 C, near White Sulphur Springs, W. Va.

[c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (c).
2. Orthothetes chemungensis (r).
3. Chonetes scitulus (c).
4. Productella lachrymosa (c).
5. Schizophoria striatula (r).
6. Leiorhynchus mesicostale (r).
7. Spirifer disjunctus (r).
8. Delthyris mesicostalis (c).
9. Amboccelia gregaria (r).
10. Sphenotus sp. (r).
11. Leptodesma extenuatum (r).
12. L. naviforme (r).
13. L. potens var. juvene (r).
14. Aviculopecten sp. (r).
15. Modiomorpha quadrula (r).
16. Loxonema sp. (r).
17. Phacops rana (r).

Between White Sulphur Springs and Caldwell the following material was obtained:

Faunule of section 1380 D, three-fourths of a mile west of White Sulphur Springs.

1. Buchiola speciosa (abundant).
2. Plethospira socialis (abundant).

Faunule of section 1380 E, at side of wagon road, 1¼ miles west of White Sulphur Springs.

1. Buchiola speciosa (common).
2. Panenka sp. (rare).
3. Styliola fissurella (abundant).

Faunule of section 1380 F, one-half mile east of Howard station.

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis var. arctostriatus (a).
2. Chonetes scitulus (a).
3. Camarotœchia cf. contracta (r).
4. Spirifer disjunctus (r).
5. Leptodesma rogersi (c).

The higher members of the series, which follow the fossiliferous beds of 1380 E, appear to be entirely barren of fossils. The red, green, and black shales, which constitute these higher beds, are well exposed near Caldwell, W. Va., station 1381 A.

CALDWELL, GREENBRIER COUNTY, W. VA.

The following section was noted in the cut just east of Caldwell:

Section 1381 A, east of Caldwell, W. Va.

	Ft.	in.
9. Alternating green and reddish shale	40	0
8. Blue to black or green shale	0–4	0
7. Greenish shale	4 to 10	0
6. Sandstone	6	0
5. Soft greenish-blue shale	1	6
4. Hard green shale	9	0
3. Blue to black banded shale	5	0
2. Bluish-green clay, with iron concretions	7	0
1. Gray to bluish heavy-bedded sandstone	1	6

The westerly dip of these varigated shales carries them below the level of the railroad about a mile and a half west of Caldwell, and the Mississippian ("Lower Carboniferous") limestone appears above them.

COVINGTON, ALLEGHANY COUNTY, VA.

The time spent at Covington was devoted mainly to collecting from the beds of the following section:

Section 1382 B, one-half mile southeast of the blast furnace on the north bank of Jackson River.

	Feet.
4. Black carbonaceous shale (Romney)	30
3. Greenish-gray shale	15
2. Coarse sandstone ("Oriskany")	3–6
1. Limestone (Lewistown)	15–25

The limestone cliff (1) on river bank, one-half mile below iron furnace, Covington, Va., contains the following species:

Faunule of zone 1 of section 1382 B, near Covington, Va.

[a, abundant; c, common; r, rare.]

1. Chætetes sp. (c).
2. Crinoid stem (r).
3. Lichenalia sp. (c).
4. Stropheodonta sp. (r).
5. Leptæna rhomboidalis (a).
6. Orthis sp. (r).
7. Rhipidomella oblata (c).
8. Gypidula pseudogaleata (r).
9. Uncinulus mutabilis (c).
10. U. nobilis (r).
11. Eatonia peculiaris (c).
12. Rhynchonella sulciplicata (r).
13. Rensselæria æquiradiata (r).
14. Spirifer concinnus (a).
15. S. murchisoni (c).
16. Trematospira multistriata (r).
17. Meristella subquadrata (c).
18. Avicula sp. (r).
19. Platyceras robustum (r).
20. Platyostoma ventricosum (?) (r).

The coarse sandstone (2) contains the following species:

Faunule of zone 2 of section 1382 B, near Covington, Va.

[a, abundant; c, common.]

1. Dalmanella planiconvexa (r).
2. Rhipidomella musculosa (r).
3. R. cf. oblata (r).
4. Rensselæria ovoides (a).
5. Spirifer cf. arenosus (r).
6. Spirifer murchisoni (c).
7. Meristella lata (r).

The greenish shale (3) yielded the following forms:

Faunule of zone 3 of section 1382 B, near Covington, Va.

[c, common; r, rare].

1. Zaphrentis sp. (r).
2. Schizophoria cf. striatula (r).
3. Atrypa spinosa (r).
4. Amboccelia umbonata (c).
5. Bellerophon sp. (r).
6. Pleurotomaria sp. (r).
7. Conularia sp. (r).
8. Phacops rana (c).

From the black shale (4), 25 to 30 feet above the Oriskany, the following species were collected:

Faunule of zone 4 of section 1382 B, near Covington, Va.

[a, abundant; c, common; r, rare.]

1. Strophalosia truncata (r).
2. Orthothetes chemungensis var. arctostriatus (c).
3. Leiorhynchus limitare (a).
4. Nucleospira cf. concinna (c).
5. Anoplotheca acutiplicata (c).
6. Buchiola speciosa (a).
7. Clinopistha cf. antiqua (r).
8. Nucula corbuliformis (c).
9. N. cf. lirata (r).
10. Nuculites triqueter (r).
11. Leptodesma sociale (r).
12. L. sp. (r).
13. Actinopteria sp. (r).
14. Pleurotomaria sp. (r).
15. Styliola fissurella (a).
16. Tentaculites gracilistriatus (a).
17. Coleolus tenuicinctus (c).
18. Hyolithes aclis (c).
19. Agoniatites vanuxemi (r).
20. Parodiceras discoideum (r).

The black shale (5), about 50 feet above the Oriskany, yielded the following forms:

Faunule of zone 5 of section 1382 B, near Covington, Va.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea cf. lodiensis var. media (r).
2. Anoplotheca acutiplicata (c).
3. Panenka (?) sp. (r).
4. Styliola fissurella (a).
5. Tentaculites gracilistriatus (a).

About one-half mile north of Covington, at the side of the wagon road, just opposite the blast furnace (1382 A), the limestone (1) of the section given above is again well exposed to a thickness of about 65 feet. The following species were obtained:

Faunule of section 1382 A, near Covington, Va.

[a, abundant; c, common; r, rare.]

1. Lichenalia cf. torta (c).
2. Stropheodonta cf. beckii (c).
3. Orthothetes woolworthanus (r).
4. Uncinulus mutabilis (c).
5. Rensselæria æquiradiata (c).
6. Cyrtina rostrata (r).
7. Spirifer concinnus (a).
8. S. cf. cyclopterus (r).
9. Avicula cf. communis (r).
10. Diaphorostoma ventricosum (r).

West of Covington fossils were collected from the dark sandy shales which lie above the typical black shale at the following stations: 1382 C, west bank of Jackson River, one-fourth mile south of Chesapeake and Ohio Railway bridge at Covington, and 1382 D, hard, bluish-green shale, one-fourth mile west of Covington, on roadside. This is a somewhat higher horizon than 1382 C. The faunules obtained from these outcrops (Jennings) are as follows:

Faunule of section 1382 C, near Covington, Va.

[a, abundant; c, common; r, rare.]

1. Paracardium doris (a).
2. Coleolus sp. (c).
3. Hyolithes sp. (r).
4. Goniatites sp. (r).

Faunule of section 1382 D, near Covington, Va.

[c, common; r, rare.]

1. Paracardium doris (c).
2. Buchiola speciosa (c).
3. Nucula corbuliformis (c).
4. Palæoneilo sp. (r).
5. Pterochænia fragile (c).
6. Goniatites sp. (r).

HOT SPRINGS, BATH COUNTY, VA.

Hot Springs is about 25 miles north of Covington. Immediately northwest of the springs the Paleozoic beds, from the Devonian black shale to the Cambrian, have been tilted until they stand almost vertical. The "black shale" is not all black, some of the lower beds being a pure creamy white in color. A bed of very hard cherty sandstone, 50 or 60 feet in thickness, lies at the base of the black shale. This formation, which stands vertical here, resists weathering more effectively than those on either side, and resembles the ruins of a massive wall running up the side of the mountain.

All of the fossils collected at Hot Springs are from the beds above the sandy chert exposed along the railroad northwest of Hot Springs.

The section at Hot Springs northwest of the springs, along the Chesapeake and Ohio Railway, is as follows:

Section 1383 A, at Hot Springs, Va.

	Feet.
9. Dark greenish to drab-colored shale, just below section house, about 1¾ miles below Hot Springs	25
8. Dull bluish-gray shales	30
7. Tough sandy black shale, below automatic switch No. 1	60
Concealed	150
6. Ash-colored shale	10
5. Black and gray shales alternating	40
Concealed	60
4. Ash-colored shale	50
Concealed	60
3. White or cream-colored clay shale	9
2. Black shale (Romney)	10
1. Hard cherty sandstone ("Oriskany")	50–60

The following lists show the faunal associations disclosed in the several zones of this section (Romney-Jennings):

Faunule of zone 2 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Orbiculoidea doria (c).
2. Chonetes cf. coronatus (r).
3. Anoplotheca cf. acutiplicata (a).
4. Styliola fissurella (c).

Faunule of zone 3 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Crinoid stem (r).
2. Orbiculoidea doria (r).
3. Pholidops sp. (c).
4. Anoplia sp. (c).
5. Bellerophon leda (r).
6. Styliola fissurella (a).
7. Coleolus sp. (r).
8. Goniatites sp. (r).
9. Ostracods (c).

Faunule of zone 4 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis var. arctostriatus (a).
2. Chonetes cf. setigerus (r).
3. Leiorhynchus limitare (a).
4. Anoplotheca sp. (c).
5. Buchiola speciosa (a).
6. Actinopteria epsilon (r).
7. Styliola fissurella (a).
8. Tentaculites gracilistriatus (a).
9. Goniatites sp. (r).

Faunule of zone 5 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Tropidoleptus carinatus (r).
2. Anoplotheca sp. (r).
3. Ambocœlia umbonata (a).
4. Actinopteria sp. (c).

Faunule of zone 6 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Chonetes setigerus (r).
3. Leiorhynchus cf. laura (r).
4. Ambocœlia umbonata (r).
5. Buchiola speciosa (c).
6. Nucula lirata (c).
7. Pterochænia cf. fragile (large var.) (r).
8. Actinopteria epsilon (c).
9. Styliola fissurella (a).
10. Tentaculites gracilistriatus (a).
11. Coleolus tenuicinctus (r).
12. C. sp. (r).
13. Parodiceras discoideum (c).

Faunule of zone 7 of section 1383 A, at Hot Springs, Va.

[c, common; r, rare.]

1. Paracardium doris (c).
2. Pararca transversa (r).
3. Nucula sp. (r).
4. Orthoceras sp. (r).

Faunule of zone 8 of section 1383 A, at Hot Springs, Va.

[a, abundant; c, common; r, rare.]

1. Buchiola speciosa (c).
2. Palæoneilo constricta (r).
3. Pterochænia fragile (a).
4. Coleolus acicula (r).
5. Orthoceras sp. (r).

Faunule of zone 9 of section 1383 A, at Hot Springs, Va.

1. Pararca transversa (rare).
2. Panenka sp. (rare).
3. Pterochænia fragile (rare).

CLIFTON FORGE, ALLEGHANY COUNTY, VA.

The following section is exposed near the Chesapeake and Ohio Railway bridge just west of Clifton Forge:

Section 1384 A, near Clifton Forge, Va.

	Feet.
3. Ash-colored shale	125
2. Soft coarse brown sandstone ("Oriskany")	15
1. Hard blue limestone with chert bands in lower layers	80
Total	220

The coarse sandstone ("Oriskany") one-half mile west of Clifton Forge contains the following faunule:

Faunule of zone 2 of section 1384 A, one-half mile west of Clifton Forge, Va.

[a, abundant; c, common; r, rare.]

1. Stropheodonta sp. (r).
2. Leptæna rhomboidalis (r).
3. Rhipidomella cf. cumberlandiæ (r).
4. R. musculosa (r).
5. Eatonia peculiaris (r).
6. Rensselæria cumberlandiæ (r).
7. R. ovoides (a).
8. Cyrtina rostrata (r).
9. Spirifer cf. arenosus (r).
10. S. murchisoni (c).
11. Anoplotheca cf. flabellites (r).

No collecting was done in the beds above or below this sandstone.

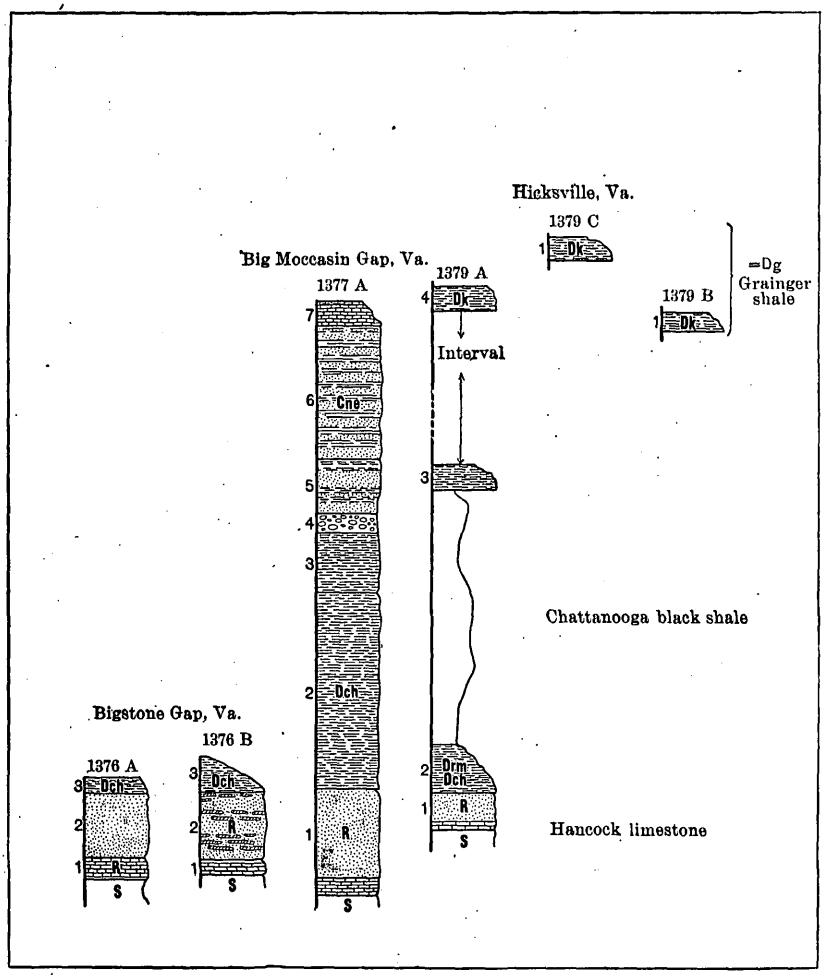


FIG. 3.—Sections in Virginia and West Virginia.

COMMENTS ON SECTIONS.

By H. S. WILLIAMS.

The facts here presented are chiefly valuable for the statistics themselves, viz, the detailed analysis of a number of local faunules. A word may be added, however, to indicate the bearing of these statistics upon the general problems of correlation, and upon the determination of the particular horizon to which each fauna should be assigned.

On the ordinary basis of correlation (i. e., the presence of species which have heretofore been recorded from some definite geological horizon) it is easy to indicate the general position of the several zones in the geological column. This general classification is indicated by the lettering of the separate parts of the sections which are arranged in approximately parallel order. (See sections, pp. 16, 28, 43.)

In this arrangement the capital letters O, S, R, D, and C are employed, with the following meaning: O indicates Ordovician; S indicates Silurian, not later than Niagara in age; R, the formation containing the Rensselæria fauna, called Giles formation in the Pocohontas folio, Hancock formation in the Estillville folio, the upper sandy portion of it being called Monterey sandstone on several of the Virginia and West Virginia sheets; D is used to indicate the Devonian formations as low as the Jeffersonville limestone of the Indiana survey; C indicates formations in which Carboniferous faunas are recognized.

On the east side of the Cincinnati arch there appears to be an unconformity at the base of the black shale. West of it (in Indiana, Tennessee, southern Illinois, and Arkansas) a limestone occasionally occurs conformably below the black shale. This limestone has a fauna which appears in the New York Onondaga limestone, and sometimes it contains traces of the *Tropidoleptus* fauna of the Hamilton formation of New York. Where this limestone occurs the unconformity appears below it.

There is considerable irregularity in the age of the formation immediately underlying the unconformity. In most of the western Kentucky and Indiana sections the underlying formation is Silurian and carries a Niagara fauna, but in some of the Kentucky sections, as well as in northern Arkansas, the highest formation below the unconformity is Ordovician. In the more eastern sections in Virginia and West Virginia the Rensselæria fauna is found in some of the uppermost Silurian formations immediately below the black shale. In western Tennessee, and also westward beyond Arkansas in Indian Territory,[a] traces of the Rensselæria fauna also appear.

It has not been definitely proved that there is an unconformity below the formation containing the Rensselæria fauna, but in both

[a] Girty, G. H., Preliminary report on Paleozoic invertebrate fossils from the region of the McAlester coal fields, Indian Territory: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1899.

cases the faunal evidence suggests this interpretation. More evidence will be required before safe generalizations can be drawn as to the sequence of faunas in this part of the area.

CORRELATIONS.

By H. S. WILLIAMS.

The limestone and the terminal Silurian sandstone of the Estillville folio are undoubtedly the constituent parts of the "Hancock limestone" of that folio. The Hancock limestone is described as thinning out to the southeast, and in the correlation given by Campbell, it is the equivalent of the Meniscus limestone of Safford and of the Oriskany and Lower Helderberg of Stevenson.[a]

The Giles formation of the Pocohontas quadrangle is correlated with the Lower Helderberg and Oriskany by Mr. Campbell.[b] In northern and central Virginia the Lewistown limestone, including the chert lentil, is correlated with the Lower Helderberg, Salina, and Niagara, and the Monterey sandstone is correlated with the Oriskany.[c]

Mr. Darton describes the underground erosion of the Lewistown limestone as follows:

> The limestones are cavernous and many extensive caves have been discovered. One of them, the Blowing Cave, is in a small anticline traversed by Cowpasture River, 6 miles west of Panther Gap. * * * Springs, sinks, and other evidences of underground drainage are of general occurrence in the limestone area.

In this region the thickness of the Lewistown limestone varies from 550 to 1,080 feet, and that of the Monterey sandstone from 50 to 200 feet.

It will be noticed also that the black shale caps the series in all the sections described in all this part of the Appalachian province.

In Maryland the lower member is called Helderberg and varies from 750 to 900 feet in thickness, followed by black chert lentils. The next formation is the Oriskany, 325 to 350 feet thick, which is capped by the black shales of the Romney formation.[d]

These definitions are consistent with the following generalization: Upon a more or less pure limestone terrane of varying thickness (the Hancock, Lewistown, Helderberg) was deposited a cherty limestone which becomes sandy and ends in coarse sandstone, occasionally described as conglomerate; above these are the cherty lentils of the limestone (Giles formation or Monterey sandstone); above these is the base of the extensive Devonian black shale (Chattanooga, Romney).

In most cases there is more or less distinct evidence of underground solution of the limestone underlying the black shale. From a forma-

[a] Geol. Atlas U. S., folio 12.
[b] Campbell, Geol. Atlas U. S., folio 26.
[c] Darton, Geol. Atlas U. S., folio 61.
[d] Clark, W. B., Maryland Geol. Survey, Allegany County, 1900.

tional point of view the evidence favors the hypothesis that the waters which produced the erosion entered through the outcrops of the porous sandstone zone, and, percolating downward, took out the calcareous portion of the rocks unevenly, the sandstones settling as erosion proceeded; the amount of erosion being determined, partly at least, by the arenaceous admixture with the limestone. The irregular thickness was probably determined by the local position of the rocks relative to flowage of water through them.

In the more southern exposures erosion has been greater than in Maryland, northern Virginia, and West Virginia. The association of the iron ores with the sandstone portion of the formation may also be accounted for by the inwash of ferruginous waters into the cavernous interior from the surface, after the underground erosion had taken place. This interpretation is further borne out by the paleontological evidence.

THE RENSSELÆRIA FAUNA.

By H. S. WILLIAMS.

In the following table the species from each of the zones immediately underlying the black shale are tabulated. Twelve faunules are listed, and they are arranged approximately in their order from south to north. They are listed together on account of their evident faunal association, and because they are not separable on formational lines; that is, species which in the more northern sections are strictly associated with the calcareous and lower members of the series are, in the southern sections, included in the sandy beds. They may have been arenaceous beds which originally were calcareous sandstone, out of which the calcareous material has been leached by percolating waters after the edges of the beds were exposed to the surface drainage. The fauna is called in this paper the Rensselæria fauna, and includes species which have been referred to the Lower Helderberg and Oriskany formations as they were originally defined in the New York reports.

The Rensselæria fauna of the Appalachians.

[a, abundant; c, common; r, rare; L, Lower Helderberg; O, Oriskany.]

	Sections.												Range in New York formations.
	1376.					1379.		1380.	1382.		1384.		
	A1.	A2.	B2.	C.	E.	A1.	X.	A2.	B1.	B2.	A1.	A2.	
1. Zaphrentis sp	.....	r	r	.....	r	.....	.....	.....	.....	.....	.....	.....	.....
2. Cyathophyllum sp	.....	.....	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....
3. Cystiphyllum sp	.....	.....	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....
4. Calceola cf. plicata	.....	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....	.....
5. Favosites sp	.....	r	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....
6. F. cf. Cladopora sp	.....	.....	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....
7. Aulopora sp	.....	.....	r	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The Rensselæria fauna of the Appalachians—Continued.

[a, abundant; c, common; r, rare; L, Lower Helderberg; O, Oriskany.]

	Sections.												Range in New York formations.
	1376.					1379.		1380.	1382.		1384.		
	A1.	A2.	B2.	C.	E.	A1.	X.	A2.	B1.	B2.	A1.	A2.	
8. Chætetes sp									c				
9. Aspidocrinus scutelliformis			r				a						L
10. Crinoid fragments								r	r				
11. Lichenalia cf. torta									c		c		L
12. Stictopora sp			r										
13. Polypora sp			r										
14. Fenestella sp					r								
15. Roemerella grandis			r										O
16. Pholidops cf. arenaria						c							O
17. Stropheodonta beckii	r		c								c		
18. S. lincklæni			r										O
19. S. magnifica			c										O
20. S. cf. planulata	r												L
21. S. sp						r			r			r	
22. Strophonella cavumbona	r	r	c										L
23. Leptæna rhomboidalis	c	c	a	r		r			a			r	
24. Orthothetes woolworthanus		r	c										L
25. Hipparionyx proximus								r					O
26. Chonetes sp. nov						r							
27. Anoplia nucleata						c							O
28. Orthis sp						r		c	r				
29. Dalmanella planiconvexa		r	r					c		r			
30. Rhipidomella cumberlandiæ												r	O
31. R. musculosa								a		r		r	O
32. R. oblata	r	c	a	r					c	r			L
33. Gypidula pseudogaleata	r		r	c	c				r				L
34. Amphigenia cf. elongata						r							
35. Rhynchotrema formosum			r										L
36. Camarotœchia ventricosa		a	a	c									L
37. Uncinulus campbellanus			r										L
38. U. mutabilis									c		c		L
39. U. nobilis									r				L
40. Eatonia peculiaris								c	c			r	
41. E. pumilla								c					O
42. Rhynchonella acutiplicata			c										L
43. R. altiplicata	c			r									L
44. R. oblata								r					O
45. R. sulciplicata									r				L
46. R. sp						r							
47. Rensselæria æquiradiata									r		c		L
48. R. cumberlandiæ												r	O
49. R. cf. marylandica								r					O

The Rensselæria fauna of the Appalachians—Continued.

[a, abundant; c, common; r, rare; L, Lower Helderberg; O, Oriskany.]

	Sections.											Range in New York formations.
	1376.					1379.		1380.	1382.		1384.		
	A1.	A2.	B2.	C.	E.	A1.	X.	A2.	B1.	B2.	A1.	A2.	
50. R. mutabilis	r		r										L
51. R. ovoides								a		a		a	O
52. R. sp			r										
53. Beachia cf. suessana								c					O
54. Atrypa reticularis			r		r								
55. Cyrtina dalmani	r	c	c										L
56. C. rostrata											r	r	O
57. Spirifer arenosus						c		a		r		r	O
58. S. concinnus									a		a		L
59. S. cumberlandiæ				c		a							O
60. S. cyclopterus		a	a				r						
61. S. murchisoni								c	c	c		c	O
62. S. (Delthyris) cf. perlamellosus					r								L
63. S. sp			r					r			r		
64. Reticularia fimbriata			r										O
65. Amboccelia sp						r							
66. Trematospira multistriata									r				L
67. Nucleospira sp	r					r							
68. Anoplotheca cf. dichotoma						r							O
69. A. cf. flabellites								c				r	O
70. Meristella cf. bella			r										L
71. M. lata								r		r			O
72. M. lævis	c	c											
73. M. subquadrata	r		c	c	c				c				L
74. M. sp			r				r						
75. Avicula cf. communis			r						r		r		L
76. Cyrtolites (?) expansus					r								O
77. Loxonema sp			r										
78. Holopea antiqua			r										L
79. Platyceras cf. gebhardi					c			r					
80. P. robustum									r				L
81. P. pyramidatum		r											L
82. P. sp	r												
83. Diaphorostoma ventricosum						r		r	r		r		
84. Tentaculites elongatus	r	r				r							
85. T. sp					r								
86. Proetus protuberans		r											L
87. P. sp			r										
88. Homalonotus sp			r										
89. Phacops cf. cristata			r	r									O
90. P. logani			c										L
91. Dalmanites cf. anchiops				r	r								O
92. D. pleuroptyx				r									O

It will be observed by reference to the descriptive part of this paper that the zones 1376 A2, 1376 B2, 1379 A1, 1379 X, 1380 A2, 1382 B2, 1384 A2 are at present sandstone, often coarse-grained; the other zones are more or less calcareous.

The species which are peculiar to the Oriskany in New York are generally confined to the sandstone, but this is not always the case, nor are peculiar Helderbergian fossils restricted to the calcareous beds. In the New York sections *Aspidocrinus* appears in the "Shaly limestone" or "*Scutella* limestone" of the early reports, while in both sections in which it occurs in Virginia (Bigstone Gap 1376 B2 and Rocky Gap 1379 X) it is found in sandy beds. At Rocky Gap (1379 X) it occurs in a coarse sandstone similar to the typical Oriskany of New York.

It is evident that the subdivisions of the Rensselæria fauna, which in the northern Appalachian region have determined the division of the strata into numerous separate formations, are not universal. Future investigations probably will show that the composition of the local faunules is determined rather by environmental conditions recorded by the differing characters of the sediments than by actual epochs in their history.

THE BLACK SHALE AND ITS FAUNA.

By H. S. Williams.

It will be noted that while the New Albany shale reaches a thickness of 100 feet in Indiana, it thins out and is often not represented along the axis of the Cincinnati-Nashville arch. On the eastern side of this arch it thickens again eastward, and along the Appalachian channel is very thick. The "Chattanooga" shale attains a thickness of several hundred feet, and runs up into coarser and more irregular beds, known as the Grainger shale in southern, and as the Romney shale in northern, Virginia and West Virginia. The fauna of the pure black shale is very meager in both species and specimens.

At Louisville (1357 A3) the black shale contains *Lingula spatulata* and *Schizobolus concentricus*. Northeast of Brooks, Ky. (1365 A3), it holds *Leiorhynchus quadricostatum*, *Chonetes scitulus*, *Lingula spatulata*, and a small *Pleurotomaria*. In the Bigstone Gap region (1376 B3) it contains *Schizobolus concentricus* and *Lingula ligea*. In Bland County, Va., along Kimberling Creek (1379 A2), *Schizobolus truncatus* appears in rocks which are there classified as Romney shales, but which are only a few feet above the base of the Giles formation, which contains the Oriskany type of the Rensselæria fauna. The same species occurs in a similar black shale one-half mile north of Hicksville, Va., and is characteristic of the black shales of the White Sulphur Springs section (1380 A4).

If the list of species is taken as a whole it becomes evident that the fauna is the one represented in the Genesee shales of New York. This interpretation would appear to be confirmed by the faunule (1367 A) at Huber, Bullitt County, Ky., in which *Reticularia fimbriata*, *Athyris spiriferoides*, and *Tropidoleptus* occur in the limestone directly under the black shale. The reported range of the fauna as given in Schuchert's list of brachiopods is as follows:

Range of black shale species.

Lingula spatulata	Genesee-Portage.
L. ligea	Hamilton-Portage.
Schizobolus concentricus	Genesee.
Chonetes scitulus	Marcellus-Chemung.
Leiorhynchus quadricostatum	Genesee.
And a Pleurotomaria sp.	

The sequence of faunas at Hot Springs, Bath County, Va., presents another view of the case. There (1383 A) both *Anoplia* and *Anoplotheca* occur in the black shales, which are over 100 feet thick and lie below the zone (A5) which contains *Tropidoleptus carinatus;* and no species of either of those two genera is listed higher than the Onondaga (Corniferous) limestone. There is thus evidence that at Hot Springs the black shale sedimentation occurred as low as the Onondaga formation. Such a conclusion is confirmed by the presence in the faunule 1383 A4, of *Leiorhynchus limitare* and *Tentaculites gracilistriatus* (both regarded as confined to the Marcellus shale of New York) and *Anoplotheca.* This conclusion is also supported by the composition of the faunule of zone 1382 B4, a typical black shale within 30 feet of the top of the Rensselæria fauna, in which are found *Anoplotheca acutiplicata* (listed as an Onondaga (Corniferous) species) with *Leiorhynchus limitare* and *Agoniatites vanuxemi*, both listed as Marcellus species. Such facts indicate that the black shale was deposited in a thick mass in the Appalachian trough before the fauna of the Onondaga (Corniferous) formation was extinct.

As the sections are followed upward, the shales become coarse and flaggy and contain faunas which in New York occupy the formations from Onondaga upward to Chemung. The formations holding similar faunas in western Kentucky and Indiana, west of the Cincinnati arch, are calcareous at the base.

The fauna of the Sellarsburg beds contains traces at least of the fauna of the Hamilton formation of New York State, and thus furnishes reason for classifying the black shales of that region with the Genesee of New York.

THE BUCHIOLA SPECIOSA FAUNA.

By H. S. WILLIAMS.

Another argument for the belief that in the regions here discussed the black shales range from as low as the Onondaga to and beyond the base of the Carboniferous, is found in the distribution among them of forms which in New York State are listed as Nunda (Portage) species.

Take, for instance, the faunules containing *Buchiola speciosa*. They appear in black, shaly sediments and in the coarser shales following them in the middle Appalachian region. But a glance at the faunule lists shows that they belong to a general fauna which in New York is sometimes seen in one or other of the Marcellus, Genesee, and Nunda[a] formations, and only in insignificant proportions in any of the other formations, occupying the part of the column between the Marcellus to the Chemung.

For some of the species the range is lower or higher than these limits. From both the association in the faunules, and the absence of common genera of other formations of this part of the Devonian, it is fair to infer that *Buchiola speciosa*, *Pterochænia fragile*, *Paracardium doris*, *Parodiceras discoideum*, *Styliola fissurella*, *Tentaculites gracilistriatus*, and some other associated species, constitute a fauna which persisted for a considerable portion of middle Devonian time, represented in the New York sections by the formations from Marcellus to Nunda, inclusive.

The following table exhibits the association of the species of the *Buchiola speciosa* fauna in the Virginia faunules and their reported range in the formations of New York:

The Buchiola speciosa fauna represented in the Virginia sections and its reported range in the New York formations.

[a, abundant; c, common; r, rare; C, Chemung; G, Genesee; H, Hamilton; I, Ithaca; M, Marcellus; O, Onondaga; N, Nunda; W, Waverly.]

	Section.										Range in New York formations.
	1380.			1382.			1383.				
	B1.	D1.	E1.	B4.	C1.	D1.	A4.	A6.	A7.	A8.	A9.	
1. Orthothetes chemungensis var. arctostriatus	....	....	....	c	....	....	a	....	....	....	....	H.
2. Chonetes cf. setigerus	....	....	....	....	....	....	r	r	....	....	....	M, W.
3. Strophalosia truncata	....	....	....	r	....	....	....	....	....	....	....	H, N, I.
4. Leiorhynchus laura	....	....	....	....	....	....	....	r	....	....	....	M, H.
5. L. limitare	....	....	....	a	....	....	a	....	....	....	....	M.
6. Amboccelia umbonata	....	....	....	....	....	....	....	r	....	....	....	M, C.
7. Nucleospira cf. concinna	....	....	....	c	....	....	....	....	....	....	....	O, H.
8. Anoplotheca acutiplicata	....	....	....	c	....	....	c	....	....	....	....	O.
9. Clinopistha cf. antiqua	....	....	....	r	....	....	....	....	....	....	....	O.
10. Paracardium doris	r	....	....	....	a	c	....	....	c	....	....	N.
11. Buchiola speciosa	a	a	a	a	....	c	a	c	....	c	....	H, G, N.

[a] See footnote on p. 86.

The Buchiola speciosa fauna represented in the Virginia sections and its reported range in the New York formations—Continued.

[a, abundant; c, common; r, rare; C, Chemung; G, Genesee; H, Hamilton; I, Ithaca; M, Marcellus; O, Onondaga; N, Nunda, W, Waverly.]

	Section.											Range in New York formations.
	1380.			1382.			1383.					
	B1.	D1.	E1.	B4.	C.	D.	A4.	A6.	A7.	A8.	A9.	
12. Pararca transversa									r		r	C.
13. Panenka sp			r								r	
14. Nucula corbuliformis				c		c						H, C.
15. N. cf. lirata				r				c				H.
16. Nuculites triqueter				r								M, H.
17. Palæoneilo brevis	r											?.
18. P. constricta										r		H, N, C.
19. Leptodesma sociale				r								C.
20. Pterochænia fragile						c		r		c	r	M, H, G, N, C.
21. Actinopteria epsilon							r	c				C.
22. Plethospira socialis		a										
23. Styliola fissurella			a	a			a	a				M, G.
24. Tentaculites gracilistriatus				a			a	a				M.
25. Coleolus acicula							r					G.
26. C. tenuicinctus				c				r				H.
27. Hyolithes aclis				c								H.
28. Orthoceras bebryx var. cayuga	r											C.
29. Agoniatites vanuxemi				r								M.
30. Parodiceras discoideum	c			r	r	r		c				H.

The association of the several species of the Virginia faunules indicates the homeotopic relationship of the faunules, and leaves little room for doubt that no one of the species can be regarded as universally diagnostic of any particular zone of the middle Devonian, but for purposes of correlation indicates only some portion of the wide range of time expressed by the series of formations named.

THE FAUNULES, THEIR RANGE AND ENVIRONMENT.

By H. S. Williams.

An examination of the separate faunules brings out their relationship to each other, and also the relation between the faunal contents and the purity of the black-shale sediments.

In the lower part of these black shales of Virginia and West Virginia their normal fauna is present, as is shown in the faunules 1376 B3, 1379 A2, 1380 A4, 1382 B4 and B5, 1383 A2 and A3, which contain the following species:

Lingula ligea.
Schizobolus concentricus.
S. truncatus.
Chonetes scitulus.

These species occur in the southern sections, where the fine-grained black shale rests immediately upon the limestones. The shales are the typical Chattanooga shales.

The black shale at Hot Springs, Va., contains the following species:

Faunule of black shale of Hot Springs, Va.

1. Orbiculoidea doria.
2. Chonetes cf. coronatus.
3. Anoplotheca cf. acutiplicata.
4. Styliola fissurella.

This follows the hard cherty sandstones which stratigraphically represent the Oriskany.

The section at Covington presents 15 feet of gray shale between the top of the sandstone (Oriskany) and the black shale (1382 B4). The black shale (1382 B4 and B5) contains the following species:

Faunule of black shale at Covington, Va.

[a, abundant; c, common.]

1. Orbiculoidea lodiensis var. media.
2. Orthothetes chemungensis var. arctostriatus.
3. Leiorhynchus limitare (a).
4. Nucleospira concinna.
5. Anoplotheca acutiplicata (c).
6. Clinopistha antiqua.
7. Buchiola speciosa (a).
8. Nucula corbuliformis.
9. N. cf. lirata.
10. Nuculites triqueter.
11. Leptodesma sociale.
12. Actinopteria epsilon.
13. Styliola fissurella.
14. Tentaculites gracilistriatus.
15. Coleolus tenuicinctus.
16. Hyolithes aclis.
17. Agoniatites vanuxemi.

This fauna presents a combination of species not generally found in the New York formations, where the Marcellus, Genesee, and Nunda formations carry fairly distinct faunas. The dominant characteristics of the fauna are its Pteropods and *Buchiola speciosa*. Although it carries *Leiorhynchus limitare* in abundance, *Buchiola speciosa* is also abundant.

There are a few other zones holding evidently the same fauna, which lie higher up in the black shales of the more northern sections. I will select these on the basis of presence of *Buchiola speciosa*, either common or abundant. (See the chart, p. 5.)

1380 B1 adds the following species to the list above:

1. Paracardium doris.
2. Palæoneilo brevis.
3. Orthoceras bebryx var. cayuga.
4. Parodiceras discoideum.

1380 D1 adds *Plethospira socialis* and an unidentified *Loxonema*.

1380 E1 adds nothing.

1382 D1 adds *Pterochænia fragile* and *Goniatites*.

1383 A4 adds *Chonetes setigerus*.

1383 A6 adds the following species:

A small Zaphrentis.
Leiorhynchus cf. laura.
Amboccelia umbonata.
Coleolus sp.
Parodiceras discoideum.

1383 A8 adds *Palæoneilo constricta* and *Coleolus acicula*.

None of these species are abnormal to the fauna. The association of species is characteristic of the Nunda formation[a] of New York, but there are a few species from a lower horizon.

In the Virginia section the fauna occupies the zone of coarse shales succeeding the pure, fine, smooth black shales, and from its stratigraphic position represents the fauna of the Nunda formation of New York. The rocks belong to the Romney and Jennings formations.

The sequence of sedimentation is regular, and there is a gradual change from pure, fine-grained black shale up to coarser and more arenaceous shale. These conditions are characteristic of the Grainger shales in which occur the *Buchiola speciosa* fauna.

Except for the greenish shale, 15 feet thick, of the Covington section, there is scarcely a trace of the faunas characteristic of the richly fossiliferous Onondaga (Corniferous) and Hamilton formations of New York, and it is evident from the fauna that follows that its horizon is not lower than the Nunda of New York. The greenish shale (1382 B3) underlying the black shale with this fauna in the Covington section contains a distinct fauna which is as follows:

Faunule of greenish shale at Covington, Va.

1. Schizophoria sp.
2. Atrypa spinosa.
3. Ambocœlia umbonata.
4. Phacops rana.

These species are indicative of a fauna ordinarily lower than the Nunda formation.[a] But the association of species alone, with the knowledge we now have of the range of the species of the Hamilton formation of New York, does not fix the age of this faunule with precision, since it is known to recur above the Ithaca fauna, and after species characteristic of the Chemung have appeared. Thus the faunal analysis indicates, not a regular succession of diverse faunas, but an interrupted succession of several faunas, each of which is recognized in the normal New York series, but the observed order of which does not strictly correspond with that characteristic of the standard New York sections.

It becomes necessary then to suppose interruption and replacement of faunas and a recurrence of early faunas at horizons above their (supposed) normal positions. This state of things has been elaborated in the study of the New York Devonian, but the detailed facts regarding these middle and southern Appalachian faunas is not sufficiently well known to make an exact correlation with the former possible at the present time.

[a] See footnote on p. 86.

Faunal chart of the Devonian formations of the middle Appalachians.

[a, abundant; c, common; r, rare; o, represented by undetermined species.]

	1376	1379.					1380.														1382.					1383.								Range values of species.							
	B3	A2	A3	A4	B	C	A4	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	D	E	F	B3	B4	B5	C	D	A2	A3	A4	A5	A6	A7	A8	A9	O	M	H	G	N	I	C	W
Zaphrentis sp.											o										o								o											
Crinoid stems.																											o													
Lingula ligea	a										r																								H		N			
Orbiculoidea doria																										c	r								H					
O. cf. lodiensis var. media																							r												M				C	
O. neglecta				c		o			c				o																										C	
Schizobolus concentricus	a																																			G				
S. truncatus		c					a																																	
Craniella hamiltoniæ										r																									H	G				
Pholidops sp.																											c													
Stropheodonta demissa											r				r	r																				H				C	
S. (Douvillina) mucronata										a	c	a	c		a	c	r																							a C	
S. (Leptostrophia) perplana v. nervosa											c																											N		C	
Strophonella cælata												r																												C	
Orthothetes chemungensis										r	r			c			r																							C	
O. chemungensis var. arctostriatus																				a		c						a							H					
Chonetes cf. coronatus																										r									H					
C. scitulus				a											a	c	r			a														M					C	
C. setigerus						a																						r		r				M						W
Anoplia sp.																											o													
Productella hirsuta				o	c					o		a	a			r																							C	
P. lachrymosa														a			c																						C	
P. cf. spinulicosta															c																			o		H					
P. stigmata						c																																	C	
P. cf. subalata										r																								Middle Devonian.						
Strophalosia truncata																						r														H		N	I		
Dalmanella tenuilineata					r							c	r																										C	
D. tioga		\								a	c				r																							b N	I	C	
Schizophoria striatula											r	c		c			r				r													o		H			I	C	
Camarotœchia contracta				a	c	c				o				c						r																		N		W
C. duplicata					a	r																																	C	
C. sappho				r						c																									M					C
Leiorhynchus laura									a	a		r		r																r					M	H				
L. limitare																						a						a							M					
L. mesicostale															c		r																					N		C	
Tropidoleptus carinatus																													r						M	H				
Atrypa hystrix											r																												C	
A. reticularis											a					r																		O					C	
A. spinosa											a	r	c		r	a					r														O					C	
Cyrtina hamiltonensis											c	r	r																							H		N			
Delthyris mesicostalis								r	c					a			c																						c I	C	
Spirifer disjunctus				c		r				c	a	a	a		r	r				r																			C	
Amboccelia gregaria								a	a		c	a				r																							C	
A. umbonata					c																c								a	r				M					C	
Anoplotheca acutiplicata																						c	c			a		o	o					o						
Nucleospira concinna																						c												o		H					
Clinopistha cf. antiqua																						r												o							
Grammysia cf. bisulcata					r																															H					
G. subarcuata				c	r										o																									C	
Buchiola speciosa							a								r			a	a			a			c			a		c		c				H	G	N			
Panenka sp.																			o				o										o					N			
Paracardium doris							r																	a	c						c								N			
Pararca transversa																															r		r							C	
Nucula corbuliformis																						c			c						o					H				C	
N. cf. lirata																						r								c						H					
Nuculites triqueter																						r													M	H					
Leda diversa															r																					H					
Palæoneilo bisulcata												c	r		o																					H					
P. brevis			r					r		o					a	c									o															C	
P. constricta															r																	r				H		N		C	
P. filosa												r	r		r																									C	
P. plana													r																							H				C	
Macrodon chemungensis														r	o																									C	
Actinopteria boydi										c				o									o							o						H					
A. epsilon																												r		c									C	
A. cf. eta											r																													C	
A. perstrialis											r																													C	
Aviculopecten sp.						o				o			o		o		o																								
Crenipecten sp															o																										
Leptodesma complanatum					o								r		o								o																	C	
L. extenuatum																	r																							C	
L. cf. juvens				r		r											r																							C	
L. lichas													c	r																										C	
L. matheri				r																																				C	
L. naviforme																	r																							C	
L. potens				a	r	r																																	C	
L. protextum													r																											C	
L. rogersi																				c																H					
L. sociale																						r																	C	
Pterochænia fragile																								c					r		a	r			M	H	G	N		C	
Lyriopecten cf. tricostatus										r		r																												C	
Mytilarca chemungensis				c	c					r					r																									C	
M. regularis						r																																		C	
Pterinea (Vertumnea) reversa											c																													C	
Pterinopecten sp											o					o																									
Cyricardella sp												o																												
Edmondia cf. philipi					r								r																										C	
E. cf. rhomboidea										r																													C	
E. subovata															r																									C	
E. transversa															r																									C	
Modiomorpha subalata var. chemungensis				r	r																																		C	
M. quadrula					o												r																						C	
M. subalata																																				H				
Nyassa cf. arguta				r	r																															H				
Goniophora chemungensis				r																																			C	
Spathella sp.													r																											
Sphenotus contractus				r		o											o																							C	
S. ? undatus																r																								C	
Phthonia sp.													o																											
Loxonema sp.																	o																							
Euomphalus sp.			o																																				
Pleurotomaria sp.															o						o	o																		
Plethospira socialis																		a																				N		
Bellerophon leda																					o					r										H				
Coleolus acicula															o									o			o			o		r						N		
C. tenuicinctus																						c								r						H				
Hyolithes aclis																						c		o												H				
Styliola fissurella																		a				a	a			c	a	a		a					M		N			
Tentaculites gracilistriatus																						a	a					a		a					M					
Conularia sp.																					o																			
Parodiceras discoideum			o				c								o							r		o	o		o	o		c						H				
Agoniatites vanuxemi							o															r													M					
Orthoceras bebryx var. cayuga					o		r																							o	o								C	
Echinocaris															o																									
Ostracods																											o													
Phacops rana																	r				c														H					

[a] See footnote on p. 35.

[b] See foot note on p. 36.

[c] See footnote on p. 58.

THE UPPER DEVONIAN FAUNAS OF THE MIDDLE APPALACHIANS.

By H. S. WILLIAMS.

In order to exhibit the relation of the Upper Devonian faunas in this region to what goes before, it is sufficient to begin with the typical black shales and to consider in connection with them the faunules up to the first appearance of Carboniferous forms.

In the accompanying chart, representing the range of the species of the upper Devonian faunas for the Virginia and West Virginia region, the fauna of the black shale is tabulated in biological order with the species which follow it, so as to exhibit the changes in the bionic relations of the successive faunas and their replacement by new species of each of the genera which pass upward.

DISCUSSION OF THE CHART.

In the chart heavy lines separate the several continuous sections, which are represented by the numbers at the top. The local section is indicated by a capital letter; the particular zone of the section in which the faunule occurs is shown by the figure following the capital letter.

The bionic value of the species recorded for each faunule is indicated by the letters used in marking its presence, viz, r=rare, a=abundant, c=common, and o indicates that a representative of the genus occurs, the specific relation of which is indeterminate from the specimens in hand. The species are grouped so as to express their biological affinities, except under each genus the species are recorded in alphabetical order. The known range value of the species is indicated by the capital letters in the column at the extreme right. O=Onondaga, M=Marcellus, H=Hamilton, G=Genesee, N=Nunda,[a] I=Ithaca, C=Chemung, W=Waverly.

The chart shows the faunal combinations and vertical range of species, as far as they can be determined from the collections at hand. These data are still too imperfect to serve as a basis for a conclusive judgment concerning the local peculiarities of the range and distribution of the species, but they suggest points toward which future investigation may be directed.

In all the sections studied the fauna of the Hamilton formation of New York is conspicuous for its meagerness or total absence. In the more southern sections the fauna of the New York Chemung is likewise scant or absent.

Some, if not all, of the species from the Hamilton fauna recur above the Hamilton formation in the typical New York sections.

[a] See footnote on p. 86.

Other Hamilton species appear as low as the Marcellus; and, as has already been stated, there is evidence of a common fauna tying together the Genesee and Marcellus, thus suggesting a separation of the typical *Tropidoleptus* fauna of the Hamilton from the *Buchiola speciosa* fauna already mentioned. The *Buchiola speciosa* fauna is seen in greater purity and with a fuller list of species in the southern sections, where the black shale sediments dominate the column for a greater vertical extent than at the north.

More facts are needed to fully differentiate these two faunas, but the dissections already made strongly suggest the probability that the faunas were contemporaneous over a great portion of their life history, and that the conditions of the sea bottom determined their geographical distribution as well as the particular zones in the stratigraphical column in which the one or the other appears.

The *Buchiola* fauna prevails wherever the Devonian black shale sedimentation was dominant, while the *Tropidoleptus* fauna exhibits its fullest development in the sediment composed of a fine-grained argillaceous mud, often more or less calcareous and typically rather light colored. A similar intercalation of two faunas is observed where the Trenton and Utica formations meet.

In the Virginia area under consideration the *Buchiola* fauna ranges above as well as below the *Spirifer disjunctus* zone. In New York *Spirifer disjunctus* is generally regarded as strictly indicative of the higher part of the upper Devonian, but it is not restricted to this horizon in Iowa, Nevada, and Arizona if the morphological affinity of *Spirifer whitneyi* and *S. disjunctus* is recognized, as is necessary when an attempt is made to correlate American with European faunas. Nevertheless the lower limit of the Chemung may be well distinguished in eastern North America by the first appearance there of *Spirifer disjunctus* and its normally associated fauna.

The significance, therefore, of the prevalence in the region under investigation of the *Buchiola* fauna up to the first appearance of *Spirifer disjunctus* is found in the inference that not only the *Tropidoleptus* fauna is there deficient, but that there is no distinct evidence of its immediate homeotopic successor, the fauna of the Ithaca member of New York.

LIST OF DIAGNOSTIC CHEMUNG SPECIES.

By H. S. WILLIAMS.

In the list below are given the species appearing in this southern extension of the fauna, which in New York are diagnostic of the Chemung formation and immediately follow the Nunda (Portage) formation:[a]

List of Chemung species.

1. Stropheodonta (Douvillina) mucronata.[b]
2. Strophonella cælata.
3. Productella hirsuta.
4. P. lachrymosa.
5. P. stigmata.
6. Dalmanella tioga.
7. Atrypa hystrix.
8. Spirifer disjunctus.
9. Delthyris mesicostalis.
10. Sphenotus contractus.
11. Edmondia, several species.
12. Macrodon chemungensis.
13. Leptodesma lichas, and several other species.
14. Mytilarca chemungensis.
15. Pterinea (Vertumnia) reversa.

The significant feature of the list is the absence of *Stropheodonta* (*Leptostrophia*) *interstrialis* Vanuxem, which is represented in the Ithaca faunas of New York; of *Spirifer pennatus* var. *posterus*, also an Ithaca species, and of the *Productella* which has generally been recorded as *P. speciosa*,[c] and was described from the Chemung of western New York. This form is, however, frequent in the Ithaca formation, and the characters which have served to distinguish it from the form coming later in the Chemung, i. e., *P. lachrymosa*, are as follows:[d]

> Umbo [is] much elevated above the hinge line, with the apex closely incurved, regularly arcuate from beak to base, and more rapidly curving to the sides; abruptly depressed on the sides of the umbo, and concave between it and the narrow, short ears.[c] * * * The species resembles some of the forms of *P. lachrymosa*, but the spiniferous tubercles are smaller, more closely arranged, and more numerous, while the umbo of the ventral valve is narrower and somewhat abruptly alternate.[e]

Figures 2, 4, 5, and 8 of Pl. XXV of the report above cited well express these features. The forms of the Chemung which have like surface markings are found to resemble more closely the figured specimens of *P. hirsuta*. Great variation is expressed in even a small collection of specimens from either horizon, and, while it is impossible to distinguish absolutely the earlier from the later forms, the characters above referred to are found in practice to be of considerable diagnostic value.

The range of *Dalmanella tioga* ("*Schizophoria tioga*") is given in Mr. Schuchert's list as "Portage and Chemung" (Dev.)."[f] After considerable study of the range values of the Devonian species, the writer

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[a] See footnote, p. 86.
[b] See note, p. 35.
[c] See Pal. N. Y., IV, 1867, p. 175, pl. 25, figs. 1–11.
[d] Ibid., page 175.
[e] Ibid., page 176.
[f] Bull. U. S. Geol. Survey No. 87, p. 375. See p. 36.

has come to the conclusion that this species does not occur in the New York sections until the Chemung fauna enters that province, thus marking the transition between the Nunda (Portage) formation[a] and the Chemung. This conclusion, which is founded on evidence furnished by numerous sections exhibiting continuous strata across the transition, causes the Erie shale of Leroy, Ohio, to be assigned to a horizon as high as the Chemung of New York, rather than in the Nunda (Portage). No trace of this species has been reported, so far as the writer is aware, from the Ithaca member or any equivalent horizon. Hence the species may be regarded as diagnostic of the Chemung formation, and not of the Nunda (Portage).

Delthyris mesicostalis is quoted by Schuchert as appearing in "Ithaca and Chemung (Dev.)."[b] If it be assumed that *Spirifer pennatus* Conrad var. *posterus*, H. & C.[c] and *Delthyris mesicostalis* Hall[d] are generically distinct they may be distinguished by the absence or very rudimentary condition of the median septum in the ventral valve of *Spirifer pennatus* var. *posterus* and its distinct development in *Delthyris mesicostalis*. If this is used as a distinguishing feature for specimens which are very similar in most other characters, it has been ascertained by the writer and those associated with him in Devonian studies that the specimens occurring at the horizon called the Ithaca member in central New York, and in all other regions where it is distinctly traced, belong to the form described as *Spirifer pennatus* var. *posterus*, and that specimens with a distinct septum do not appear in the sections until the incoming of the Chemung fauna above the Nunda (Portage) formation. Hence the species described as *Delthyris mesicostalis* Hall should be quoted as a diagnostic Chemung species, and as not occurring in the Ithaca member.[e]

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[a] See footnote, p. 86.
[b] Bull. U. S. Geol. Survey No. 87, p. 207.
[c] Pal. New York, Vol. VIII, Pt. II, p. 361.
[d] Geol. New York, Rept. Fourth Dist., 1843, p. 269.
[e] See further notes on pp. 75, 76, 108.

CONTRIBUTIONS TO DEVONIAN PALEONTOLOGY, 1903.

PART II.

FOSSIL FAUNAS OF DEVONIAN SECTIONS IN CENTRAL AND NORTHERN PENNSYLVANIA.

BY

HENRY SHALER WILLIAMS and EDWARD M. KINDLE.

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PART II.—FOSSIL FAUNAS OF DEVONIAN SECTIONS IN CENTRAL AND NORTHERN PENNSYLVANIA.

By H. S. WILLIAMS and E. M. KINDLE.

PREFACE.

By H. S. WILLIAMS.

The sections discussed in the following pages were chosen for the purpose of extending the detailed knowledge of the faunas of the Devonian in a southeasterly direction across the beds from central New York, where the writer had already accumulated considerable evidence of their order and composition, to central Pennsylvania.

The facts already known suggested the probability that in Devonian time a shore line to the southeast limited the basin in which the sediments accumulated and the forms lived; they also led to the expectation that there would be a modification of the faunas to some degree, according to their distance from the shore line.

While the writer planned and directed the investigations, Doctor Kindle examined the sections and collected and identified the fossils. In the interpretation of the facts we have worked together and have reached the same conclusions. To the discussion, however, we have each contributed. The preparation of charts and faunal lists and method of treatment has been, in general, under the direction of the senior author, but the junior author has contributed many valuable suggestions and has done the most valuable part of the work—the gathering and elaboration of the facts themselves.

The following sections have been examined, and the order of succession and composition of the temporary faunules analyzed and reported for each:

The Catawissa section, East Bloomsburg, Columbia County, Pa., about 76° 30′ west longitude, and a little south of 41° north latitude.

The Hollowing Run section, lower Augusta Township, Northumberland County Pa., about at intersection of 76° 50′ and 40° 45′.

The Leroy section, composed of four shorter sections at Gulf Brook, near Leroy, Bradford County, Pa., Granville Center at South Mountain, the opposite side of the Towanda Creek from Leroy, and Towanda Narrows, about 6 miles east of Leroy. The general position of the section is near the intersection of 76° 45′ W. and 41° 45′ N.

The Tioga section, along Tioga River, near village of Tioga, Tioga County, Pa., near the intersection of 77° 10′ W. and 41° 50′ N.

The Mansfield ore bed section, about 8 miles south of Mansfield, Tioga County, Pa.

The Canoe Camp section, several miles still farther south on east side of Tioga River.

The Armenia Mountain section, two miles west of Troy, in Bradford County, Pa.

The last four sections belong together, though their actual continuity is not established by continuous sections. The system of recording and designating the faunules and their bionic values here adopted is the same as that employed and more elaborately defined in Bulletin United States Geological Survey, No. 210, "The Correlation of Geological Faunas."

INTRODUCTION.

By E. M. KINDLE.

The two methods of correlation of stratified rocks which are in use are based upon the comparison and similarity of faunas and of rock sections. In their application one or the other of these methods is generally employed to the partial or entire neglect of the other. The paleontologist and the geologist have usually not the time or the inclination to make a minute study, respectively, of all the faunules or beds of a section. The two methods are supplementary, and neither can yield its best service in correlation when used independently of the other.

The ideal section from the standpoint of both correlation and faunal geology should show the thickness and character of the rocks and the lists of the species at each locality. The close relationship of the biological and the physical elements of the section are expressed in the accompanying sections. Both the paleontological and the stratigraphical data have been combined in the same section. The relation of the several elements of the faunas or the species to the section is indicated by the range and comparative abundance of each species.

The comparison of faunas can not give the most satisfactory results for purposes of correlation until the history of the faunas compared is fairly well known. Changing conditions of environment constantly

affect the distribution of the species of a fauna. The succession of advantageous and adverse conditions of life at a given locality leads to the frequent shifting of position of some of the individuals of a fauna, and sometimes to the migration of the entire fauna. The overlap of faunas, the change in the composition of faunas at different horizons, and the modification of species in ascending can be studied in a satisfactory manner only in connection with the rock sections in which these changes are recorded. It is believed that the present method of presenting paleontological and stratigraphical data in faunal cross sections will throw much light on such problems and be most effective in working out the life history of faunas.

The accompanying sections are intended primarily as a contribution to our knowledge of the geographical distribution and geological range of Devonian fossil faunas, and as an aid in the correlation of the upper Devonian formations of Pennsylvania and New York.

THE CATAWISSA SECTION, COLUMBIA COUNTY, PA.

DESCRIPTION OF SECTION.

By E. M. KINDLE.

Susquehanna River cuts across the strike of the southward-dipping beds of the Montour anticline between the town of Catawissa and East Bloomsburg station, exposing in a continuous section the beds of the Devonian from the Hamilton formation up to the lowest "red beds." The work of the river in exposing the strata, which dip southward at an angle of 35° to 45°, has been supplemented by the construction of the Pennsylvania Railroad along its east bank, and the resulting section is probably not surpassed, if equaled, by any other in Pennsylvania in the opportunity which it affords for the study of upper Devonian faunas.

The lithological characteristics of the several beds are shown in the accompanying detailed section, which is followed by lists of the fossils obtained from each fossiliferous zone.

Section 1453 A, at Catawissa, Pa.[a]

		Ft.	in.
72.	(1) Red shales, dip S. 10 E. 30°–35°	50	0
71.	(2) Sandstone, greenish, massive, visible	10	0
70.	(3) Concealed	110	0
69.	(4) Greenish-gray sandstones, some shaly and also some reddish-brown sandstones	200	0
68.	(5) Sandstone, gray, massive	10	0
67.	(6) Red shale, sandy	100	0

[a] Numbers in parentheses refer to corresponding divisions of White's section, Second Pennsylvania Geol. Survey, Rept. G 7, p. 285.

		Ft.	in.
66.	(7) Sandstone, green, flaggy	40	0
65.	(8) Shales, red, sandy	30	0
64.	(9) Sandstone, green	10	0
63.	(10) Red shales, sandy	60	0
62.	(11) Green sandstone	15	0
61.	(12) Red shales	55	0
60.	(13) Greenish sandstone	10	0
59.	(14) Sandstone, green, current-bedded	10	0
57.	(16) Red shales	90	0
56.	(17) Sandstone, greenish-gray, massive	25	0
55.	(18) Concealed with red and green bands, occasionally seen	120	0
54.	(19) Sandstone, massive, greenish-gray	15	0
53.	(20) Red shales	175	0
52.	(21) Sandstone, massive, greenish-gray	50	0
51.	(22) Concealed	70	0
50.	(23) Brecciated limestone with fish remains	5	0
49.	(24) Olive shales, sandy at top	40	0
48.	(25) Red shale	12	0
47.	(26) Concealed mostly, dip 35° to 40° S. 10° E	550	0
46.	(27) Olive shales	175	0
45.	(28) Concealed	275	0
44.	(29) Olive shales	90	0
43[a]	(30) Red shales	10	0
42.	(31–34, 35? & 36?) Olive-gray shales and sandstone, mostly covered	225	0
41.	(37) Sandy, olive-green shales	15	0
40.	(37) Fossiliferous band	0	6
39.	(37 in part) Hard, greenish-olive, sandy shale	30	0
38.	Beds as above	4	0
37.	Hard, olive-gray, sandy shale, with fossils common	60	0
36.	Hard, olive-gray, sandy shale	30	0
35.	Greenish-gray, fossiliferous shale	2	0
34.	Hard, sandy, greenish-gray shales	75	0
33.	Greenish-gray, sandy shale, fossiliferous at top	25	0
32.	Hard, olive-gray, sandy beds	95	0
31.	Olive-gray, sandy beds, with fossils	5	0
30.	(41–44 in part) Olive-gray, hard, sandy beds, with occasional beds of crinoid stems	185	0
29.	(45?) Hard, olive-gray, sandy beds, weathering to rusty brown	100	0
28.	Bluish-gray, sandy beds, with two bands of large concretions	15	0
27.	Dark bluish-gray, hard, sandy beds	63	6
26.	Fossiliferous sandy beds	3	6
25.	Bluish-gray sandy beds	18	0
24.	Fossiliferous band	0	6
23.	Bluish-gray, hard, sandy shale	20	0
22.	Hard, bluish-gray sandy beds, with large concretions, fossiliferous at top	18	3
21.	Calcareous, fossiliferous bed	0	6
20.	Hard, sandy, olive-gray beds, with large concretions near top	60	0
19.	Bed of *Spirifer pennatus* var. *posterus*	0	3
18.	Olive-gray sandy beds	35	0
17.	Calcareous bed of fossils	1	0

[a] The section above 43 is given as published by I. C. White, Second Pennsylvania Geol. Survey, Rept. G 7, p. 285.

	Ft.	in.
16. Olive-gray sandy beds	25	0
15. (67?) Dark olive-gray sandy beds, with two highly fossiliferous bands	30	0
14. (68) Hard, dark bluish-olive sandy beds	70	0
13. (68 in part) Hard, dark bluish-olive sandy beds, fossils common	25	0
12. (69) Beds as above, nearly barren of fossils	91	0
11. (69) Beds as above, fossiliferous band at top	54	0
10. (69) Beds as above with fossiliferous band at top, apparently barren elsewhere	75	0
9. (69 in part) Hard, sandy, olive-gray beds, with 3 to 4 inch band of fossils at top	80	0
8. (70) Olive-gray sandy beds, breaking with splintery fracture	60	0
7. (71) Dark olive-brown sandy beds	20	0
6. (72) Olive-brown and bluish, hard, sandy beds (fossils near base)	175	0
5. (73) Dark blue, shaly, sandy beds	25	0
4. (74) Bluish-black fissile shale	225	0
3. (75) Hard, bluish-gray calcareous shale, weathering buff or ash-gray	25	0
2. (76 and 75 in part) Mostly covered	25	0
1. (76 upper part) Hard, sandy, dark bluish-drab shales	25	0

FAUNULES OF THE CATAWISSA SECTION.

By E. M. KINDLE.

Zone 1 of Catawissa section (1453 A).—The lowest beds of the section outcrop in the bed and bank of the river at East Bloomsburg. They contain the following species:

Faunule of zone 1 of Catawissa section (1453 A).

[a, abunbant; c, common; r, rare.]

1. Pleurodictyum problematicum (r).
2. Stropheodonta (Douvillina) inæquistriata (r).
3. Pholidostrophia iowensis (r).
4. Chonetes coronatus (c).
5. Rhipidomella vanuxemi (c).
6. Leiorhynchus mesicostale (r).
7. Tropidoleptus carinatus (largest specimens nine-tenths of an inch wide) (a).
8. Spirifer granulosus (specimens large, and typical of the species) (a).
9. S. medialis (S. audaculus) (c).
10. S. pennatus (a).
11. Meristella cf. nasuta (r).
12. Palæoneilo emarginata (r).
13. P. plana (r).
14. Actinopteria decussata (r).
15. Aviculopecten sp. (r).
16. Modiomorpha cf. concentrica (r).
17. Cypricardella bellistriata (r).
18. Cyclonema hamiltoniæ (c).

The species composing this faunule are all characteristic Hamilton forms. This lowest zone of the section corresponds most closely, both in its fossils and lithology, with the typical Hamilton formation of New York State.

Zone 3 of Catawissa section (1453 A).—The beds of this zone, following those of zone 2 which are mostly covered, are well exposed along

the railroad on each side of the small ravine at East Bloomsburg, and contain the following faunule:

Faunule of zone 3 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Zaphrentis cf. simplex (r).
2. Cystodictya cf. bifurcata (r).
4. Fenestella sp. (c).
4. Stropheodonta sp. (r).
5. Dalmanella tenuilineata (r).
6. Atrypa aspera (c).
7. Ambocœlia umbonata (a).
8. Platyceras sp. (r).
9. Styliola fissurella (a).
10. Tentaculites spiculus (c).
11. Phacops rana (c).
12. Dalmanites boothi (r).
13. D. cf. anchiops (r).

The rock containing these fossils contains only a small amount of lime and is perhaps equally well described either as a calcareous shale or as a very impure argillaceous limestone.

This bed has been called the Tully limestone by the Pennsylvania survey.[a] As it lies between typical Hamilton and Genesee beds, it unquestionably occupies the stratigraphical position of the Tully limestone of New York, but all of the fossils are Hamilton species, not one of the characteristic Tully forms appearing. This is doubtless to be explained by the fact that in physical characters this bed resembles the preceding Hamilton beds as much as or more than it resembles the Tully limestone of New York. The somewhat limey character of this bed indicates an approach toward the conditions of sedimentation prevailing in the typical Tully limestone area at the close of the Hamilton epoch, but the change from the Hamilton shale type of sediments was not sufficiently complete to induce the migration of the Tully fauna into the region, nor to drive out the Hamilton fauna, so that the latter continued to exist in a modified form. Although the fauna in this zone is a Hamilton fauna, the changed conditions of a later time interval are registered by the elimination of such characteristic Hamilton types as *Spirifer granulosus* and *Spirifer pennatus*, which were among the most abundant in the preceding zone.

While this zone does not contain the Tully fauna, the modified character of the Hamilton fauna which takes its place, together with its stratigraphical position between typical Genesee shales and Hamilton beds, justify the correlation of the Pennsylvania survey.

Prosser has shown that in eastern New York, where the Tully limestone is absent, its horizon is indicated at one locality by the presence of *Hypothyris cuboides* associated with *Spirifer pennatus*.[b] In the same region Clarke has shown that where the Tully and Genesee are absent "the Hamilton fauna has perpetuated itself without interruption."[c]

[a] Second Pennsylvania Geol. Survey Rept. G 7, pp. 282, 283, 287; Final Rept., vol. 2, p. 1319.
[b] Fifteenth Ann. Rept. State Geol., New York, p. 185.
[c] Thirteenth Ann. Rept. State Geol., New York, p. 554.

Zone 4 of Catawissa section (1453 A).—Careful search has failed to discover any fossils in the black shales of this zone. The physical appearance of the beds is identical with that of the Genesee shale, and no doubt a Genesee fauna will eventually be found in this region at this horizon.

Zone 5 of Catawissa section (1453 A).—The dark-bluish shaly beds, which form a transition from the fissile shales of zone 4 to the hard sandy beds of zone 6, appear, like the former zone, to be barren.

Zone 6 of Catawissa section (1453 A).—Near the base of 175 feet of hard, olive-brown, sandy beds the following faunule appears:

Faunule of zone 6 of Catawissa section (1453 A).

[c, common; r, rare.]

1. Plant remains (r).
2. Lingula sp. (r).
3. Chonetes lepidus (c).
4. Elymella fabialis (r).
5. Buchiola speciosa (r).
6. Nuculites cf. triqueter (r).
7. N. sp. (c).
8. Pterochænia fragile (c).
9. Lunulicardium curtum (r).

In this assemblage of species we have the first appearance of the *Buchiola speciosa* (Nunda) fauna in the section, suggesting the early stage of sedimentation of the Nunda (Portage) formation.[a]

Zone 7 of Catawissa section (1453 A).—This zone is the equivalent of No. 71 of White's section, and contains the following species:

Faunule of zone 7 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Aulopora sp. (a).
2. Schizophoria striatula (r).
3. Cyrtina hamiltonensis (r).
4. Spirifer pennatus var. posterus (a).
5. Nucula bellistriata (r).
6. N. sp. (c).
7. Nuculites cf. triqueter (c).
8. Actinopteria sp. (c).
9. Leda diversa (c).
10. Pleurotomaria sp. nov. (c).
11. Macrochilina cf. hamiltoniæ (r).

The earliest appearance for this section of *Spirifer pennatus* var. *posterus* is in this faunule.

Zone 8 of Catawissa section (1453 A).—Fossils are scarce and difficult to collect at this horizon. The collection shows the following:

Faunule of zone 8 of Catawissa section (1453 A).

[c, common; r, rare.]

1. Crinoid stems (r).
2. Leiorhynchus mesicostale (c).
3. Nuculites sp. (r).
4. Palæoneilo emarginata (r).
5. P. sp. (r).
6. Leda sp. (r).

One or two individuals of *Leiorhynchus mesicostale* have the plications limited to four on the fold, and resemble *L. globuliforme.*

[a] See footnote, p. 86.

Zone 9 of Catawissa section (1453 A).—The faunule of this zone is from a 3- to 4-inch band of fossils, separated from the preceding zone by 80 feet of nearly barren beds. This zone contains the following species:

Faunule of zone 9 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (a).
2. Leiorhynchus mesicostale (c).
3. Spirifer pennatus var. posterus (c).
4. Palæoneilo emarginata (r).
5. P. cf. filosa (r).
6. Leda diversa (r).
7. Leiopteria cf. bigsbyi (r).
8. Actinopteria cf. perstrialis (c).

Three or four fragments of a small *Spirifer*, probably representing *Sp. pennatus* var. *posterus*, occur in this faunule.

Zone 10 of Catawissa section (1453 A).—At the top of 75 feet of barren beds, following zone 9, a thin fossiliferous zone bears the following faunule:

Faunule of zone 10 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Crinoid stems (c).
2. Cyrtina hamiltonensis (a).
3. Spirifer pennatus var. posterus (c).
4. Nucula sp. (r).
5. Bellerophon sp. (c).
6. Cyclonema multilira (c). (The specimens are much larger than those figured by Hall, but agree with them in other respects.)
7. Orthoceras cf. fulgidum (r).

The association of the recurrent Hamilton forms, *Cyrtina hamiltonensis* and *Sp. pennatus* var. *posterus*, as dominant forms in this and other faunules of this section, is paralleled by the association of the same species in the Ithaca fauna of the Ithaca section. Above this zone, which is 435 feet above the Genesee shale of this section, *Sp. pennatus* var. *posterus* appears in most of the faunules up to the top of the section. This variety first appears as a common form in the Ithaca section 380 feet above the Genesee shale of that section, and is known by the writer to continue through at least 260 feet of the Ithaca beds.

Zone 11 of Catawissa section (1453 A).—Following the preceding zone are 54 feet of barren or nearly barren beds, at the top of which occurs the following faunule:

Faunule of zone 11 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (a).
2. Cyrtina hamiltonensis (r).
3. Spirifer pennatus var. posterus (r).
4. Reticularia lævis (r).
5. Sanguinolites (?) sp. (r).
6. Nucula sp. (r).
7. Palæoneilo plana (c).
8. Leda diversa (r).
9. Actinopteria perstrialis (a).

This faunule is of special interest because of the presence of *Reticularia lævis*, which hitherto has not been recognized outside of a limited area in central New York.

Zone 12 of Catawissa section (1453 A).—Ninety-one feet of nearly barren olive-gray sandy beds comprise this zone. No fossils were collected.

Zone 13 of Catawissa section (1453 A).—The 25 feet of dark bluish-olive sandy beds succeeding the last zone contain the following species:

Faunule of zone 13 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Chonetes scitulus (a).
2. Productella cf. speciosa (r).
   (Two very small Productellas are doubtfully referred to this species.)
3. Camarotœchia eximia (a).
4. Leiorhynchus mesicostale (c).
5. Cyrtina hamiltonensis (c).
6. Spirifer mesistrialis.
7. S. pennatus var. posterus (a).
8. Nucula sp. (r).
9. Modiomorpha subalata var. chemungensis (?) (r).
   (A single small specimen referred to this species with some doubt).
10. Cypricardella gregaria (c).

Zone 14 of Catawissa section (1453 A).—Seventy feet of nearly barren sandy beds intervene between the last-mentioned and the succeeding fossiliferous zone. In this zone are found the following species:

Faunule of zone 14 of Catawissa section (1453 A).

[c, common; r, rare.]

1. Palæoneilo constricta (r).
2. P. plana (r).
3. Actinopteria perstrialis (c).
4. Loxonema cf. læviusculum (r).
5. Coleolus acicula (r).
6. Orthoceras cf. fulgidum (r).
7. O. sp. (r).

Zone 15 of Catawissa section (1453 A).—The fossils occurring in this zone are as follows:

Faunule of zone 15 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Crania leoni (r).
2. Chonetes scitulus (r).
3. Productella speciosa (r).
4. Cryptonella eudora (a).
5. Tropidoleptus carinatus (r).
6. Atrypa reticularis (r).
7. Spirifer mesistrialis (a).
8. S. pennatus var. posterus (a).
9. Grammysia sp. (r).
10. Macrodon sp. (r).
11. Leptodesma sp. (r).
12. Actinopteria perstrialis (r).
13. Bellerophon sp. (r).
14. Pleurotomaria sp. (c).
15. Cyclonema sp. (r).
16. Platyceras sp. (r).
17. Tentaculites spiculus (c).

The above list contains many typical fossils of the Ithaca fauna. The presence of *Tropidoleptus carinatus* in this faunule is noteworthy

as representing a very late survival in this region of a typical Hamilton species.[a]

Zone 16 of Catawissa section (1453 A).—Succeeding zone 15 are 25 feet of nearly barren beds.

Zone 17 of Catawissa section (1453 A).—This zone is composed of a mass of fossil shells 1 foot in thickness at an elevation of 1,000 feet above the base of the section.

Faunule of zone 17 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (r).
2. Paleschara sp. (r).
3. Chonetes scitulus (a).
4. Cryptonella eudora (r).
5. Atrypa reticularis (r).
6. Cyrtina hamiltonensis (c).
7. Spirifer mesistrialis (a).
8. S. pennatus var. posterus (a).
9. Amboccelia gregaria (r).
10. Actinopteria perstrialis (r).
11. Bellerophon sp. (r).
12. Cyclonema sp. (c).
13. Loxonema sp. (r).
14. Tentaculites spiculus (c).

Zones 18 to 20 of Catawissa section (1453 A).—The 35 feet of olive-gray beds (18) following the last zone are terminated above by a 3-inch band of the shells of *Sp. pennatus* var. *posterus* (19), above which comes 60 feet of hard sandy beds (20) with few fossils and with a bed of large concretions near the top.

Zone 21 of Catawissa section (1453 A).—A 6-inch band of calcareous rock contains the following faunule:

Faunule of zone 21 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp.
2. Cystodictya meeki (c).
3. Cyrtina hamiltonensis (a).
4. Spirifer mesistrialis (a).
5. S. pennatus var. posterus (c).
6. Amboccelia gregaria (r).

Zone 22 of Catawissa section (1453 A).—The species comprising the faunule of zone 22 are the following:

Faunule of zone 22 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Leptostrophia) interstrialis[b] (r).
2. S. (L.) perplana var. nervosa (a).
3. Schizophoria striatula (r).
4. Cyrtina hamiltonensis (c).
5. Spirifer mesistrialis (c).
6. S. pennatus var. posterus (c).

Zone 23 of Catawissa section (1453 A).—Twenty feet of nearly barren beds follow the last horizon.

[a] With the exception of that species the faunule is very similar to one occurring in the middle part of the Ithaca member at Ithaca.—H. S. W.

[b] See footnote, p. 35.

Zone 24 of Catawissa section (1453 A).—A fossiliferous band 6 inches thick contains the following faunule:

Faunule of zone 24 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Crania sp. (r).
2. Stropheodonta (Leptostrophia) interstrialis (c).
3. S. (L.) perplana var. nervosa (a).
4. Chonetes setigerus (r).
5. Schizophoria striatula (c).
6. Cyrtina hamiltonensis (c).
7. Spirifer pennatus var. posterus (a).
8. Glyptodesma erectum (r).
9. Pleurotomaria sp. (r).
10. Tentaculites spiculus (r).

Zone 25 of Catawissa section (1453 A).—This zone comprises 18 feet of bluish-gray sandy beds, sparingly fossiliferous.

Zone 26 of Catawissa section (1453 A).—Following the preceding zone are 3½ feet of beds, which hold the following faunule:

Faunule of zone 26 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (c).
2. Stropheodonta (Leptostrophia) interstrialis (r).
3. S. (L.) perplana var. nervosa (a).
4. Chonetes scitulus (c).
5. Productella speciosa (r).
6. Atrypa reticularis (a).
7. Cyrtina hamiltonensis (c).
8. Spirifer pennatus var. posterus (a).
9. Leiopteria cf. bigsbyi (r).
10. Actinopteria perstrialis (a).
11. Tentaculites spiculus (c).

The specimens here listed as *Sp. pennatus* var. *posterus* exhibit some interesting variations. Some of the specimens which represent the *posterus* type have the well-marked muscular impression in the ventral valve characteristic of this form, without any distinct trace of a median septum which characterizes the closely related form *Delthyris mesicostalis*. A few have the weakly developed median septum without the muscular impression, and represent an early stage of development of *Delthyris mesicostalis*. A majority of the specimens show both characters, the median septum being but slightly developed in any individuals.

Zone 27 to 30 of Catawissa section (1453 A).—Three hundred and sixty-three feet of nearly barren beds succeed the last zone.

Zone 31 of Catawissa section (1453 A).—Five feet of olive-gray sandy beds afford the following species:

Faunule of zone 31 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Productella speciosa (r).
2. Schizophoria striatula (a).
3. Pugnax cf. pugnus (r).
4. Atrypa aspera (r).
5. A. reticularis (c).

The third species is represented by two small fragments doubtfully referred to this species.

Zone 32 of Catawissa section (1453 A).—Ninety-five feet of comparatively barren beds intervene between the preceding and the succeeding fossiliferous zones.

Zone 33 of Catawissa section (1453 A).—The following species are from the upper part of 25 feet of greenish-gray sandy shale:

Faunule of zone 33 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (r).
2. Chonetes scitulus (r).
3. Productella speciosa (a).
4. Pugnax pugnus (c).
5. Cyrtina hamiltonensis (r).
6. Spirifer pennatus var. posterus (a).
7. Reticularia lævis (r).
8. Sanguinolites sp. (r).
9. Nucula corbuliformis (c).
10. Palæoneilo filosa (c).
11. P. plana (r).
12. Actinopteria sp. (r).
13. Bellerophon mæra (r).
14. B. (Bucanopsis) leda var. (r).
15. Pleurotomaria sp. (r).
16. Loxonema sp. (r).
17. Orthoceras sp. (r).

This faunule is noteworthy as showing a second occurrence in the section of *Reticularia lævis* nearly 900 feet above its first appearance. In the Ithaca section it is known to have a vertical range of 520 feet. *P. pugnus*, which is here associated with *R. lævis*, is another form well known in the Nunda horizon of central New York.

Zone 34 of Catawissa section (1453 A).—Seventy-five feet of hard, sandy greenish-gray shales, carrying few fossils, follow the last zone.

Zone 35 of Catawissa section (1453 A).—Two feet of fossiliferous beds hold the following species:

Faunule of zone 35 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Leiorhynchus mesicostale (a).
2. Pugnax pugnus (c).
3. Cyrtina hamiltonensis (a).
4. Spirifer pennatus var. posterus (a).
5. Grammysia sp. (r).
6. Nucula corbuliformis (r).
7. Palæoneilo filosa (r).
8. Actinopteria sp. (r).

The specimens of *Sp. pennatus* var. *posterus* in this zone have the greatly extended hinge line characteristic of those occurring at the Triphammer Falls horizon in the Ithaca section.

Zone 36 of Catawissa section (1453 A).—The beds of this zone hold the following faunule:

Faunule of zone 36 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Craniella cf. hamiltoniæ (r).
2. Productella speciosa (c).
3. Schizophoria striatula (r).
4. Leiorhynchus mesicostale (a).
5. Pugnax pugnus (c).
6. Cyrtina hamiltonensis (c).
7. Spirifer pennatus var. posterus (a).
8. Palæoneilo plana (r).

The specimens of *Sp. pennatus* var. *posterus* are rather large, averaging about 1½ inches in width.

Zone 38 of Catawissa section (1453 A).—The following species occur in the 4 feet of beds included in this zone:

Faunule of zone 38 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta cf. demissa (r).
2. Schizophoria striatula (c).
3. Leiorhynchus mesicostale (c).
4. Spirifer pennatus var. posterus (a).
5. Palæoneilo plana (r).
6. Pterinea chemungensis (r).
7. Ectenodesma birostratum (r).

Zone 39 of Catawissa section (1453 A).—Thirty feet of sparingly fossiliferous shales separate the last zone from the succeeding.

Zone 40 of Catawissa section (1453 A).—A 6-inch band of richly fossiliferous rock affords the following species:

Faunule of zone 40 of Catawissa section (1453 A).

[a, abundant; c, common; r, rare.]

1. Craniella cf. hamiltoniæ (r).
2. Stropheodonta cf. demissa (r).
3. Productella speciosa (c).
4. Schizophoria striatula (r).
5. Pugnax pugnus (a).
6. Atrypa aspera (r).
7. Cyrtina hamiltonensis (c).
8. Spirifer pennatus var. posterus (r).
9. Ambocœlia gregaria (r).
10. Nucula diffidens (c).
11. Palæoneilo cf. brevis (r).
12. Palæoneilo sp. (r).
13. Leptodesma sp. (r).
14. Mytilarca sp. (r).
15. Glyptodesma cf. erectum (r).
16. Ectenodesma cf. birostratum (r).
17. Goniophora cf. truncata (r).
18. Cypricardella cf. gregaria (r).
19. Bellerophon cf. mæra (r).
20. B. sp. (r).
21. Loxonema sp. (r).

It will be noted that nearly all of the species in this list occur in the Ithaca fauna. The third and fifth species (*P. speciosa*) and *P. pugnus*, which are the dominant forms of the faunule, are characteristic species of the Ithaca fauna. This is the latest faunule appearing in the section. No characteristic Chemung forms appear either in it or in any of the preceding faunules. It is to be observed also that this fauna ranges through approximately 1,400 feet. The pure Ithaca fauna at Ithaca occupies about 400 feet and the Chemung fauna begins less than 1,400 feet above the Genesee.

Zone 41–42 of Catawissa section (1453 A).—Olive-gray shales and sandstone, mostly covered and apparently barren, occupy the interval between the last zone and the lower "red bed."

Zone 43 of Catawissa section (1453 A).—This zone comprises 10 feet of red shales, is the lowest of the "red beds," and is barren of fossils. It is the highest bed in which careful search was made for fossils.

FORMATIONAL CORRELATION OF CATAWISSA SECTION.

By H. S. WILLIAMS.

The Catawissa section was chosen for special investigation because of its central position and because it has been adopted as a standard section in the interpretations of the geology of this and several adjacent counties. In Rept. G 7, I. C. White used it as a standard. The State geologist, J. P. Lesley, after consulting James Hall, of New York, concerning the points involved, allowed the paleontological facts to stand as reported. Criticism of the value of paleontology rather than of the correctness of the statements resulted from the confusion between the stratigraphy and the paleontology.[a]

The 10-foot bed of red shales (No. 89 of section, on p. 239 of Rept. G 7) was made the base of the Chemung-Catskill. On the north side of the river the same bed is recognized as No. 41 of the Rupert and Catawissa section.[b] I. C. White made the following statement:

> The reader will understand that the top of the Chemung has been fixed by me in the district at the base of the lowest red bed, and that all rocks below this, down to the top of the Hamilton, will be described under the name of Chemung, since I have found it impracticable to separate the Portage from the Chemung by any well-defined characters that will apply throughout the district, although it is very probable that 800′–1,000′ of the beds in the lower part of the group are the equivalent of the Portage beds in New York.
>
> The following section taken along the south bank of the Susquehanna River, beginning at the eastern end of the bridge across the latter stream at Rupert exhibits the distribution of the fossils in the Chemung.[c]

The identification of the fossils was upon the authority of Professor Claypole. In discussing the Catawissa section, I. C. White gives the following reasons for adopting this basis of classification:

> There comes at the bottom of the Catskill a series of rocks having such a mixture of Catskill and Chemung characters that it seems impossible to determine precisely the lower limits of the former, or the upper of the latter; and to bridge over the difficulty I have thought best to classify these transition beds as an intermediate Catskill-Chemung group.
>
> The base of the Catskill series, as limited in this report, has been placed at the horizon where the scales, teeth, and bones of *Holoptychius* make their first appearance.[d]
>
> Some geologists would doubtless cut off the Catskill at the base of No. 22 [of the Catawissa section] and place all the underlying portion of the section, 700′ thick, in the Chemung, because some shells of Chemung type occur in these beds; but since more than 1,000′ of red beds underlie the first bed, No. 54, at the bottom of the section, I prefer the conclusion that a few of the Chemung shells lived on, in this region at least, far into the Catskill period.[e]

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[a] See Second Pennsylvania Geol. Survey, Rept. G 7, prefatory letter, sec. 24, p. xix; also p. 63, etc.
[b] Ibid., pp. 63–64. [c] Ibid., pp. 67–68. [d] Ibid., p. 54. [e] Ibid., p. 59.

Faunal chart of Catawissa section, Columbia County, Pa.

[a, abundant; c, common; r, rare.]

	Dark arenaceous shale (Hamilton).		Hard calcareous shale (Tully).	Fissile black shale (Genesee).	Dark-gray, thin-bedded sandstone and shales (Sherburne).							Dark-gray sandy shale and sandstone (Ithaca).																											Red shale (Catskill).
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23–25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.
				100 ft. 200 ft. 300 ft.		400 ft. 500 ft.			600 ft.	700 ft.		800 ft.	900 ft.		1,000 ft.					1,100 ft.					1,200 ft.		1,300 ft.	1,400 ft. 1,500 ft.		1,600 ft.			1,700 ft.			1,800 ft.					1,900 ft. 2,000 ft.	
Pleurodictyum problematicum	r																																								
Zaphrentis cf. simplex			r																																						
Z. sp																					r																				
Aulopora sp							a																																	
Crinoid stems								r		c																														
Fenestella sp			c																																						
Paleschara sp																	r																								
Cystodictya meeki									a		a						r				c			c							r										
C. cf. bifurcata			c																																						
Lingula sp						r																																		
Crania leoni															r																										
C. sp																						r																			
Craniella cf. hamiltoniæ																																		r								
Stropheodonta cf. demissa																																				r		r			
S. (Douvillina) inæquistriata	r																																								
S. (Leptostrophia) interstrialis																						r	c	r																	
S. (Leptostrophia) perplana var. nervosa																						a	a	c																	
S. sp			r																																						
Pholidostrophia iowensis	r																																								
Chonetes coronatus	c																																								
C. lepidus						c																																		
C. scitulus													a		r		c								c							r										
C. setigerus			r																			r																			
Productella speciosa													r		r										r					r		a			c				c			
Dalmanella tenuilineata			r																																						
Rhipidomella vanuxemi	c																																								
Schizophoria striatula							r														r	c						a					r		c		r			
Camarotœchia eximia													a																												
Leiorhynchus mesicostale	r							a	c				c																						a	a		c					
Pugnax pugnus																													r		c		c	c				a			
Cryptonella eudora															a		r																								
Tropidoleptus carinatus	a														r																										
Atrypa aspera			c																										r										r			
A. reticularis															r		r								a					c												
Cyrtina hamiltonensis							r			a	r		c				c				a	c	c	c							r		a	c				c			
Reticularia lævis											r																						r										
Spirifer granulosus	a																																								
S. medialis	c																																								
S. mesistrialis													a		a		a				a	c																				
S. pennatus	a																																								
S. pennatus var. posterus							a		c	c	r		a		a		a				c	c	a	a						a		a	a				a			
Ambocœlia umbonata			a																																						
A. gregaria																	r								r													r			
Meristella cf. nasuta	r																																								
Elymella fabalis						r																																		
Buchiola speciosa						r																																		
Grammysia sp															r																										
Sanguinolites sp											r																						r										
Nucula bellistriata							r																																	
N. corbuliformis																															c		r								
N. diffidens																																						c			
N. ? sp							c				r		r																													
Nuculites nyssa						r	c			r																														
N. ? sp						c		r																																
Palæoneilo cf. brevis																																						r			
P. constricta														r																										
P. emarginata	r							r	r																																
P. filosa									r																						c		r								
P. plana	r										c			r																			r			r		r					
P. ? sp								r																													r			
Leda diversa							c		r		r																														
Leda sp								r																																
Macrodon sp															r																										
Actinopteria decussata	r																																								
A. perstrialis									c		a		c		r		r								a																		
A. ? sp							c																								r		r								
Ectinodesma birostratum																																				r		r			
Glyptodesma erectum																							r														r			
Leptodesma sp															r																						r			
Leiopteria cf. bigsbyi									r														r																
Lunulicardium curtum						r																																		
Pterochænia fragile						c																																		
Pterinea chemungensis																																				r					
Aviculopecten sp	r																																								
Goniophora cf. truncata													c																									r			
Modiomorpha cf. concentrica	r																																								
M. subalata cf. var. chemungensis																																									
Mytilarca sp																																						r			
Cypricardella bellistriata	r																																								
C. gregaria																																						r			
Bellerophon leda var.														r																r										
B. mæra																															r							r			
B. sp										c					r		r																								
Pleurotomaria sp							c								c							r								r										
P. sp. nov																																									
Loxonema cf. læviusculum													r																												
L. ? sp																	r														r							r			
Macrochilina cf. hamiltoniæ							r																																	
Platyceras sp.	r		r												r																										
Cyclonema hamiltoniæ	c																																								
C. multilira										c																															
C. ? sp															c		c																								
Styliola fissurella			a																																						
Tentaculites spiculus			a												c		c						r	c																		
Coleolus acicula														r																										
Orthoceras cf. fulgidum										r				r																										
O. ? sp														r																										
Dalmanites cf. anchiops			r																																						
D. boothi			r																																						
D. sp	r																																								
Phacops rana			c																																						
Psilophyton sp						r																																		

The above quotations make it clear that I. C. White in 1883 accepted the first substantial red bed in the Devonian sections as the upper termination of the Chemung formation, and regarded the first fish bed with *Holoptychius* remains as the base of the true Catskill formation. For practical purposes (not fully approving it himself), he proposed to call the formations lying between these two zones the Chemung-Catskill.

In this section are to be found the evidences which have been taken for the classification of the upper Devonian formations of central Pennsylvania in general, as given in the Second Pennsylvania report.

A reference to the Prefatory Letter of Report G 7 will indicate the nature of the confusion introduced. In closing that letter the State geologist (J. P. Lesley) remarks:

> The startling fossil species of this report will therefore be regarded by the paleontologist . . . as only provisionally verified; while they must certainly stimulate American geologists to a closer study, and especially to a microscopic study, of several of our so-considered plainest and least ambiguous forms.[a]

In the following year, 1884, a sharp controversy arose in section E of the American Association for the Advancement of Science over the restatement of one phase of the same problem—the claim that *Spirifer mesistrialis* and *Spirifer disjunctus* were found together in the same formation. It was at that time my good fortune to know the statement to be correct, because I had a rock specimen containing both species. But none of the geologists knew at that time the real cause of the difficulty.

It was not known then that the first red bed could not be taken as the mark of the close of the Chemung formation, so long as Chemung was identified by marine fossils, and that the first fish beds did not occur uniformly at the same horizon in relation to the succession of marine faunas.

I believe very few geologists at that time were ready to accept the proposition that fossils which were known to represent separate stages of a continuous section in one region could actually occur together in the same zone of another section. The last remark of Professor Lesley's letter has proved correct. The fossils which were of critical importance were no doubt incorrectly labeled, and the conclusions which rested upon their identification were erroneous. This at least has been demonstrated by the recent study of the Catawissa section.

The diagnostic Chemung fossil *Spirifer disjunctus*, which was reported from three zones of the section below the first red bed and from four zones in the section on the north side of the river (the lowest of which is within 800 feet of the top of the Genesee), not only has not been found after special careful search of every foot of the

[a] Second Pennsylvania Geol. Survey, Rept. G 7, p. xxvi.

section, but the fossils that do occur represent faunas which are well known in New York State, none of which contain this species in any of their reported outcrops.

Since the lists of species have been officially reported, it is not sufficient to say that the species do not occur in the section. The statement that the classification, as it stands, is not in accordance with the paleontological facts, can not be accepted in place of the official reports without demonstrative evidence. It is not just to the geologists to charge them with wrong interpretation when they were relying on the accuracy of the paleontologist's determination. It has been thought fairer and better to neglect the statistics already reported, to examine the section anew, and to gather new series of fossils.

In order that the facts may be clearly before the reader, the interpretation of the section, as given by I. C. White in the report, will be briefly stated.

The lowest red bed of the section on the north side of the river is given as No. 41 of the section.[a] It outcrops at roadside near the mouth of a little run, 280 rods north from Catawissa station. It is given as No. 30 of the section on the north side of the river, and is there described as "Red shales, sandy, near east end of Rupert Bridge of Reading Railroad, this being the lowest red bed and base of transition."[b]

This was made the top of that part of the section specially examined by Doctor Kindle, and is No. 43 of his section. A reconnaissance survey of the higher beds did not show to him any marine invertebrate fossils, so that detailed search for fossils was not made. None are reported by I. C. White for this particular section above the first red bed No. 30.

On the north side of the river, marine fossils are reported above this red bed for nearly a thousand feet. The reported species are all Chemung.[c] These higher beds are classified as Chemung-Catskill.

The thickness of the section, according to I. C. White's estimate, is as follows:[d]

Thickness of beds of Catawissa section.

	Feet.
Chemung (strata Nos. 30–73, inclusive), and from the top of the Genesee to first red bed	2,300
Chemung-Catskill, or transition, to first fish bed	1,100
Catskill	1,412

The lower 1,000 feet, or thereabouts, was identified as equivalent to the Portage on basis of fossils.[e]

The thickness of the so-called Chemung, from the Genesee shales

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[a] Second Pennsylvania Geol. Survey, Rept. G 7, p. 64.
[b] Ibid., p. 285.
[c] Ibid., p. 65.
[d] Ibid., p. 287.
[e] Ibid., p. 70.

to the base of the first red bed, Kindle estimated to be a little over 2,100 feet. No single section can be measured through the whole series, and the element of dip comes in to make up the difference in estimated thickness. Many of the zones of the original section were recognized by Kindle, but not all, and the section here reported upon is given on the basis of an independent examination and tabulation of the strata, the section, however, covers the same interval of rocks given in Rept. G 7.

The Stony Brook beds are identified in Rept. G 7 as No. 39 of the section. Whether I. C. White's identification of the beds in this section is correct or not, the Stony Brook beds were then regarded as of great value for determining horizons. I. C. White stated that the "Stony Brook horizon can be recognized anywhere within the region wherever its beds are exposed, from Luzerne County to the southern part of Northumberland,"[a] and suggests that this zone may be present 50 or 150 feet below the third Venango oil sand in Crawford and Erie counties.

The four species which are said to be "always associated in the Stony Brook beds" are *Productella hirsuta*, *Spirifer disjunctus*, long-winged form, *Spirifer mesicostalis*, and *Leiorhynchus mesicostale*.[a]

The original outcrop of the Stony Brook beds is in Columbia County, at a cutting where the road crosses Stony Brook, one-half mile north of the south line of Orange Township. The brook empties into Fishing Creek.

On the evidence of the fossils, the following statement was made concerning the Stony Brook beds: "In fact this horizon seems to represent, par excellence, the typical Chemung rocks of New York in physical aspect as well as in fossils."[b] And in the final report, ten years later, this interpretation is confirmed.[c]

As is shown in the present report (see page 76) the fossils found in the rocks at the horizon called "Stony Creek beds" by I. C. White do *not* belong to the fauna of the typical Chemung formation of New York, but to a fauna always, in the New York section, found below the typical Chemung in what, along the Cayuga Lake meridian, is called the Ithaca member. In fact the combination of species is very close to that found in the central part of the typical Ithaca member of Ithaca, N. Y. Professor Hall's surmise, that the Stony Creek beds were middle Chemung, was nearer the truth, but in making that judgment he was misled by the report that *Spirifer disjunctus* was present in the fauna. Not a trace of that species has been found anywhere in the Catawissa section.[d] The use of this bed as evidence of the upper part of the typical Chemung, as in this and several other

[a] Second Pennsylvania Geol. Survey, Rept. G 7, p. 72.
[b] Ibid., p. 92.
[c] Summary Final Rept. Second Pennsylvania Geol. Survey, vol. 2, p. 1564.
[d] See Second Pennsylvania Geol. Survey, Rept. G 7, p. xxx.

cases[a] is therefore misleading on account of misinterpretation of the fossils.

While this reliance upon wrong report of fossils has led to error, a mistake of another kind was made when I. C. White held that Chemung species occurred not only in his transition interval, called Chemung-Catskill, but also several hundred feet above the base of the Catskill.[b] This is accounted for by the supposed survival of Chemung species into the Catskill age. "But the marked absence of other well-known Chemung fossils shows that the above-mentioned species are merely five species which survived long beyond those with which they are associated in the genuine Chemung beds, into the Catskill age."[b] The same idea is conveyed in an earlier statement in which the author defends his determination of the base of the Catskill at the *Holoptychius* beds by saying: "Some geologists would doubtless cut off the Catskill at the base of No. 22, and place all of the underlying portion of the section, 700 feet thick, in the Chemung, because some shells of Chemung type occur in these beds; but since more than 1,000 feet of red beds underlie the fish bed, No. 54, at the bottom of the section, I prefer the conclusion that a few of the Chemung shells lived on, in this region at least, far into the Catskill period."[c] I quote this argument in full because it strikes at the very heart of the difficulty.

The first appearance of red beds and of *Holoptychius* in a stratigraphical section is there announced to be of more importance in determining the geological age of the beds than the presence of well-known representatives of a marine invertebrate fauna which is known to hold a definite place in the sequence of fossil faunas.

The problem may be expressed in simple terms, as follows: It is supposed that *Spirifer disjunctus* is characteristic of the Chemung fauna and red beds are typical of the Catskill formation. Where *Spirifer disjunctus* occurs in the midst of red beds I. C. White maintained that the rocks are of Catskill age and that *Spirifer disjunctus* lived on after its normal period (the Chemung). The opposite contention, which is here advocated, is that the age of the beds is Chemung and that the red beds were deposited earlier in this region than at places where they are found only above the *Spirifer disjunctus* zone of the section.

The issue was clearly recognized by me at the first reading of Report G 7, but it will be noticed at once that the question seems to be purely a matter of opinion, and there is no evidence to prove the correctness of either view. At the time of writing the report its author and the Pennsylvania survey were apparently in possession of the facts. The disregard of the interpretations by fossils was justified, since the species were incorrectly reported in a critical case. The problem could be solved only by such a perfect elaboration of the

[a] See Second Pennsylvania Geol. Survey, Rept. G 7, Pl. V., p. 66. [b] Ibid, p. 240. [c] Ibid, p. 59.

faunas that they would afford conclusive proof independent of red beds or any other purely physical characters. It has taken a long time to gather the evidence, but we are now able to prove by fossil evidence that the red beds, regarded as the top of the Chemung formation of this region by I. C. White, were deposited before the typical Chemung fauna occupied the seas of this region.

The evidence for this conclusion is found in the appearance of the Ithaca fauna immediately below the lowest red beds. This Ithaca fauna occupies the section down to within 200 feet of the black shale beds of the Genesee, where the typical Nunda fauna occurs. Below the Genesee a typical Hamilton fauna is seen. No characteristic Chemung fossils appear in the whole section at Catawissa. The successive appearance of the Hamilton, Genesee, lower Nunda, and Ithaca faunas, terminated above by red beds, demonstrates the important fact that the Catskill type of sedimentation began in this region before the Chemung epoch opened.

Professor Hall was right in stating that the beds were of Chemung age so long as they carried Chemung fossils (i. e., up to 22 of the I. C. White section). This would, however, carry the top of the Chemung formation 2,700 feet higher up than it is located in the report and would include all of I. C. White's Chemung-Catskill and 1,700 feet of his Catskill.

The present investigation has not gone far enough to positively confirm this conclusion, but the evidence afforded by the fossils of the Catawissa section that have been critically studied makes such a conclusion probable.

The facts published in the reports regarding the range of fossils in the sections are in favor of the interpretation given by Professor Hall. *Spirifer disjunctus* and other Chemung fossils were frequently reported above the base of the red beds. In the Fishing Creek section[a] fossils were reported 800 feet above the top of the so-called Chemung. In the Montour section[b] fossils were found 700 feet above the base of "Catskill" and 1,700 feet above the top of "Chemung." The Hartville section[c] (Luzerne County) shows Chemung fossils 150 feet above the base of the "Catskill."

It is evident from these reported cases that the fossils were of secondary importance in determining the upper limit of the Chemung. The first red beds, at whatever horizon they occurred, in relation to the fossils, were regarded as evidence of the top of the Chemung formation and the beginning of the Catskill series. The transition beds up to the first well-defined *Holoptychius* beds were called Chemung-Catskill.

That Professor Claypole, who identified the fossils, understood the confusion of evidence is clear from his report on Perry County. The

[a] Second Pennsylvania Geol. Survey, Rept. G 7, p. 215. [b] Ibid., p. 237. [c] Ibid., p. 196.

Kings Mill sandstone is placed in the Catskill formation, although he found in it, and in the overlying shales, fossils which he identified as typical Chemung species. The formation name was evidently applied because of the red shales and the *Holoptychius* beds, and he supposed that these beds were "passage beds between the Chemung and the Catskill, during the formation of which Catskill conditions more and more prevailed, rendering the seas less and less congenial to the Chemung fauna, until the latter became extinct; and then followed that vast accumulation of red sandstone and shale almost destitute of organic remains, except those of fishes, which is usually recognized as the Catskill formation."[a]

In conclusion it is to be noted that not a single species of the list of 15 diagnostic Chemung species mentioned on page 57 of this bulletin is found in the 2,000 feet of strata of this Catawissa section.

FAUNAL CORRELATIONS OF CATAWISSA SECTION.

By H. S. Williams.

Regarding the paleontological evidences presented in this section, the following comments may be made:

The first fossiliferous zone (1 to 3) contains the normal fauna of the Hamilton formation, as shown by the dominance of *Tropidoleptus carinatus*, *Chonetes coronatus*, *Rhipidomella vanuxemi*, *Spirifer pennatus*, *S. granulosus*, and *Phacops rana*, and the presence of *S. medialis*, *Palæoneilo emarginata*, *Modiomorpha concentrica*, *Cypricardella bellistriata*, and *Cyclonema hamiltoniæ*.

Zone 4 may be correlated, on account of its lithological similarity and in the absence of detected fossils, with the Genesee formation.

Zone 6 contains a fauna which is common in the Nunda (Portage) formation both above and below the horizon of the Ithaca fauna, and in sections in which the latter is absent. It is recognized by the presence and association of such species as *Buchiola speciosa*, *Pterochænia fragile* and *Lunulicardium curtum*. It contains *Chonetes* and *Lingula* but rarely species of any other genera of brachiopods.

The fossiliferous zone, extending from 7 to 26 inclusive, contains a fauna typical of the Ithaca member, as it is seen at Ithaca, N. Y. The diagnostic species are *Spirifer pennatus* var. *posterus*, *Sp. mesistrialis*, *Actinopteria perstrialis*, *Leiorhynchus mesicostale*, *Productella speciosa*, *Cystodictya meeki*, and *Stropheodonta* (*Leptostrophia*) *interstrialis*. The thickness here is 700 feet. At Ithaca, N. Y., the fossiliferous zone, which is characteristic, is not over 400 feet thick. *Reticularia lævis* appears in the Catawissa section 280 feet above the base of the fossiliferous zone. This first *Reticularia lævis* faunule occupies much the same position, in the sequence of development of the general

[a] Second Pennsylvania Geol. Survey, Rept. F 2, p. 76.

faunas, as in the Ithaca section. The fossiliferous zone extends about 400 feet above it in both cases; and the difference in the range of fossils, indicated by the statistics now on hand, is shown by the fact that in the Catawissa section such species as *Spirifer pennatus* var. *posterus*, *Schizophoria striatula*, and *Leiorhynchus mesicostale*, appear well below the first *Spirifer lævis* zone while in Ithaca they do not appear below it. It is noticeable that the brachiopods dominate above while in the lower 200 feet of the fossiliferous zone there are few brachiopods though there is a sparse fauna of gastropods, lamellibranchs and cephalopods. In this feature the Catawissa and Ithaca sections agree. This mingling of the two faunas, which are more sharply differentiated in the Ithaca section, is probably due to the geographical position of the section.

In western New York, along the Genesee Valley, the interval between the Genesee shale and the first appearance of the Chemung fauna is occupied by the Nunda formation, with no trace in it of the rich Ithaca fauna. Very little trace of that fauna is seen in the Seneca Lake Valley sections, while at Ithaca there is a zone of 400 feet preceded as well as followed by Nunda conditions and fauna. This zone is occupied by the rich brachiopod fauna of the typical Ithaca formation.

Points to be noted in the faunal combinations are the association of *Spirifer pennatus* var. *posterus* with *Reticularia lævis* in zone 11, and the appearance of the former over 200 feet lower in zone 7. Another interesting association is *Tropidoleptus carinatus*, in zone 15, with *Productella speciosa*, *Cryptonella eudora*, *Spirifer mesistrialis*, and *S. pennatus* var. *posterus*. This is evidently a recurrence from the Hamilton formation, and is to be correlated in time with the occurrence recorded in the Ithaca section in Bulletin 3 (page 15) of the faunule called in that report No. 14 N. The species *Tropidoleptus carinatus* does not appear in the latter zone at Ithaca so far as at present discovered, but several common Hamilton forms do.

From zone 26 upward for about 300 feet no fossils were detected, and the upper fossiliferous zone occupies the succeeding 400 feet. This upper zone (31–40) holds a fauna in which the dominant species are still those of the Ithaca beds. From 26 to 40, inclusive, may be correlated with the upper Nunda of the Ithaca section.

It will be noticed that the *Strophèodonta* is almost completely absent, a single species referred to, *S. demissa*, appearing in both 38 and 40. *Schizophoria striatula* is present, but *Cryptonella* is wanting, as is also *Spirifer mesistrialis*. *Pugnax pugnus* and *Reticularia lævis* are both present, the former frequently and in considerable numbers. *Productella hallana* is not recorded, but it probably would be found on more thorough search. These characteristics of the

upper fauna, associated with the absence of the Chemung species of *Productella*, *Orthis*, *Spirifer*, and *Delthyris*, indicate a continuation of the Ithaca fauna up through the zone, called upper Portage at Ithaca, where it was found to be nearly barren and represented only by recurrent Nunda (Portage) species.

This combination of species, seen in the upper part of the Catawissa section, is in harmony with the theory that the income of the western fauna was associated with the movements of the Nunda (Portage) sediments and fauna, while the Ithaca fauna was associated more intimately with the shiftings of the fauna of the Hamilton and is purer to the east, and is more restricted, both in species and in range, as it is followed westward across the States of Pennsylvania and New York.

Regarding the representatives of the western interior fauna, it may be said that, according to the present evidences, the *Reticularia* was the first to appear in this eastern area; then came *Pugnax* and *Productella hallana*, and at a still later incursion, *Strophonella* and *Spirifer disjunctus* were added.

It will be observed that species *Ectenodesma birostratum* and *Glyptodesma erectum* and two species of *Bellerophon* also appear in these upper faunules.

But, as Doctor Kindle has already noted, throughout this whole fossiliferous zone of the Catawissa section, up to the appearance of the characteristic red sediment of the Catskills, no characteristic Chemung species have been discovered. Using the Ithaca section as a standard, the Catawissa section, up to zone 40 (by the fossils), and presumably up to the base of the red bed 43, must be correlated with the Hamilton, Genesee, and Nunda (including the Ithaca member in the latter) formations.[a] Faunally the evidence of the Chemung formation must be looked for in the still higher strata.

THE HOLLOWING RUN SECTION, NORTHUMBERLAND COUNTY, PA.

DESCRIPTION.

By E. M. KINDLE.

A second section was selected for detailed study on Susquehanna River, 25 miles southwest of the Catawissa section.

The Pennsylvania survey, in reporting upon this section, announced the occurrence in it of *Spirifer disjunctus* "in great numbers,"[b] and correlated all the beds above the "Genesee" as "Chemung." This particular section was subjected to investigation partly in order to test

[a] The name "Nunda formation," including the Ithaca member, has been adopted in the Watkins Glen folio (now in preparation) to designate what has heretofore been called the Portage, or Nunda, group. November, 1904. H. S. W.

[b] Second Pennsylvania Geol. Survey Rept., G 7, p. 358.

the correctness of this correlation. It was desired also to compare the vertical range of the species occurring in it with those of the Catawissa and other sections, to ascertain the variation of the faunas, and to learn whether any new faunal province appeared in that direction.

For 10 miles or more below Selinsgrove the Susquehanna River cuts across the folds of the Paleozoic rocks, approximately at right angles to the strike. A very good section is exposed on the east bank of the river, between the mouth of Hollowing Run and Selinsgrove Junction, extending down to the Salina. The beds dip to the south at from 35° to 45°. The strike is S. 70° W. magnetic.

Only the upper Devonian part of this section was studied by the writer. Beginning with the lowest beds studied, the section exposed along the railway is as follows:

Section 1454 A, at Hollowing Run, Pa.

	Ft.	in.
29. Tough olive sandy shale with few fossils	20	0
28. Tough olive sandy shale with fossils	10	0
27. Hard olive to grayish sandy beds, apparently barren	70	0
26. Hard olive-grayish sandy beds with fossils	10	0
25. Shaly dark olive sandy beds with occasional bands of crinoid stems and *Stictopora*	170	0
24. Olive-gray sandy shale	5	0
23. Dark olive sandy beds	65	0
22. Band of *Stictopora*	0	2
21. Dark olive sandy beds	100	0
20. Hard olive-gray sandy beds with fossils	10	0
19. Hard olive-gray sandy beds	90	0
18. Bed of closely crowded shells	0	4
17. Bluish-gray hard sandy beds, weathering brownish, with occasional fossils	125	0
16. Bluish-gray shaly sandy beds with lamellibranch fauna	5	0
15. Dark gray sandy shales	50	0
14. Dark gray shaly sandstone, weathering splintery	10	0
13. Dark bluish sandy shale and thin-bedded sandstone, apparently barren	200	0
12. Same as above, but containing a few fossils	20	0
11. Dark bluish somewhat sandy shale	30	0
10. Dark bluish-gray shales with some hard intercalated sandy beds	110	0
9. Covered 285 paces, estimated thickness	400	0
8. Bluish-gray shale	5	0
7. Covered	18	0
6. Dark fossiliferous shale	5	0
5. Dark somewhat sandy shale	220	0
4. Covered for 40 paces, estimated thickness	75	0
3. Dark sandy shales with ferruginous concretions	90	0
2. Dark sandy shales	15	0
1. Dark sandy shale and yellow sandstone	35	0
	1,963	6

FAUNULES OF THE HOLLOWING RUN SECTION.

By E. M. KINDLE.

Zones 1–8 of Hollowing Run section (1454 A).—The dark shales of the upper five of these zones contain *Spirifer pennatus*, *Tropidoleptus carinatus*, *Chonetes coronatus*, and other characteristic species of the Hamilton formation in abundance. The purpose of the present investigation being the study of the faunas above the Hamilton, to which these zones belong, detailed collections were not made from them.

Zone 9 of Hollowing Run section (1454 A).—This zone is concealed. The 400 feet which White estimated it to represent probably include the Genesee shales and some of the Hamilton beds.

Zone 10 of Hollowing Run section (1454 A).—The 110 feet of beds of this zone appear to be entirely barren. Their lithological characters, together with their position in the section, indicate that they belong to the Nunda (Portage) formation.

Zone 11 of Hollowing Run section (1454 A).—The 30 feet of shales of this zone hold the following faunule:

Faunule of zone 11 of Hollowing Run section (1454 A).

[a, abundant; c, common; r, rare.]

1. Cladochonus sp. (r).
2. Stropheodonta (Leptostrophia) interstrialis (a).
3. Buchiola speciosa (c).
4. Palæoneilo filosa (r).
5. Macrodon cf. hamiltoniæ (r).

This faunule, like the following, is distinctly Nunda in composition.

Zone 12 of Hollowing Run section (1454 A).—This zone contains the following faunule:

Faunule of zone 12 of Hollowing Run section (1454 A).

[c, common; r, rare.]

1. Aulopora sp. (c).
2. Reticularia lævis (r).
3. Leda diversa (r).
4. Coleolus acicula (r).
5. Orthoceras bebryx var. cayuga (r).
6. Goniatites sp. (r).

Reticularia lævis is represented by two well-preserved individuals. The beds containing this interesting species outcrop 22 paces above milepost 132.

Zone 13 of Hollowing Run section (1454 A).—The 200 feet following the last zone appears to be barren.

Zone 14 of Hollowing Run section (1454 A).—This zone contains the following species:

Faunule of zone 14 of Hollowing Run section (1454 A).

[a, abundant; r, rare.]

1. Cladochonus sp. (r).
2. Crinoid stems (r).
3. Schizophoria striatula (r).
4. Leiorhynchus mesicostale (a).
5. Grammysia sp. (r).
6. Nucula sp. (r).
7. Modiomorpha cf. neglecta (r).
8. M. subalata var. chemungensis (r).
9. Pleurotomaria capillaria (r).
10. Manticoceras sp.

Zone 15 of Hollowing Run section (1454 A).—No fossils were obtained from this zone, which appears to be nearly barren.

Zone 16 of Hollowing Run section (1454 A).—Five feet of shaly beds afford the following faunule:

Faunule of zone 16 of Hollowing Run section (1454 A).

[a, abundant; c, common; r, rare.]

1. Cladochonus sp. (r).
2. Crinoid stems (c).
3. Cystodictya meeki (c).
4. Stropheodonta (Leptostrophia) interstrialis (a).
5. Chonetes scitulus (c).
6. Productella hallana (r).
7. P. speciosa (c).
8. Pugnax pugnus (c).
9. Cryptonella cf. eudora (r).
10. Atrypa reticularis (c).
11. Cyrtina hamiltonensis (c).
12. Spirifer pennatus var. posterus (a).
13. Grammysia subarcuata (r).
14. G. sp. (r).
15. Spathella typica (r).
16. Nucula corbuliformis (r).
17. Palæoneilo plana (r).
18. Leda cf. obscura (r).
19. Mytilarca carinata (r).
20. Actinopteria epsilon (r).
21. Schizodus chemungensis var. quadrangularis (r).
22. Pterinopecten sp. (c).
23. Modiomorpha subalata (r).
24. M. subalata var. chemungensis (r).
25. Murchisonia sp. (r).
26. Platyceras cf. conicum (r).
    (One small individual is referred doubtfully to this species.)
27. Tentaculites spiculus (r).
28. Coleolus acicula (c).
29. Manticoceras complanatum (c).
10. M. sp.

This faunule displays very clearly the characteristics of the Ithaca fauna. All of the brachiopods occur in the Ithaca fauna, and most of the other species are known in it. The presence of *Productella hallana*, a rare species in eastern faunas, is noteworthy.

Zone 17 of Hollowing Run section (1454 A).—One hundred and twenty-five feet of sandy beds, containing very few fossils, succeed the last zone.

Zone 18 of Hollowing Run section (1454 A).—At the top of zone 17 are 4 inches of closely crowded shells, which contain the following species:

Faunule of zone 18 of Hollowing Run section (1454 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Leptostrophia) interstrialis (c).
2. Productella speciosa (c).
3. Schizophoria striatula (a).
4. Cryptonella eudora (r).
5. Atrypa reticularis (a).
6. Cyrtina hamiltonensis (a).
7. Spirifer pennatus var. posterus (a).
8. Nucula cf. corbuliformis (r).

Zone 19 of Hollowing Run section (1454 A).—The 90 feet of beds above zone 18 contain few fossils.

Zone 20 of Hollowing Run section (1454 A).—The species comprising the faunule of this zone are the following:

Faunule of zone 20 of Hollowing Run section (1454 A).

[a, abundant; c, common; r, rare.]

1. Cystodictya meeki (a).
2. Strophеodonta (Leptostrophia) interstrialis (r).
3. Atrypa reticularis (c).
4. Spirifer pennatus var. posterus (a).
5. Spathella typica (r).
6. Palæoneilo plana (r).
7. Macrodon sp. nov. (r).
8. Pterinea cf. reproba (r.)

Zone 21 of Hollowing Run section (1454 A).—About 100 feet of dark-olive sandstone, having very few fossils, follow the last zone.

Zone 22 of Hollowing Run section (1454 A).—A 2-inch band, composed principally of a mass of *Cystodictya*, affords the following species:

Faunule of zone 22 of Hollowing Run section (1454 A).

[a, abundant; r, rare.]

1. Cystodictya meeki (a).
2. Crinoid stems (r).
3. Productella speciosa (r).
4. Pugnax pugnus (r).
5. Cyrtina hamiltonensis (r).
6. Palæoneilo sp. (r).

These species are all forms well known in the Ithaca fauna. It is to be noted that *Pugnax pugnus* occurs repeatedly in this section, as it does in the Catawissa and Ithaca sections.

Zone 23 of Hollowing Run section (1454 A).—Above zone 22 are 65 feet of sandy beds, holding few fossils.

Zone 24 of Hollowing Run section (1454 A).—The following species are from 5 feet of olive-gray shales:

Faunule of zone 24 of Hollowing Run section (1454 A)

1. Strophеodonta (Leptostrophia) interstrialis, (common).
2. Schizophoria striatula (abundant).
3. Atrypa reticularis (common).

Zone 25 of Hollowing Run section (1454 A).—One hundred and seventy feet of dark olive sandy beds, barren, except for occasional bands of crinoid stems or *Cystodictya*, follow the last zone.

Zone 26 of Hollowing Run section (1454 A).—The 10 feet of beds comprising this zone afforded only a single species, *Schizophoria striatula* which is rare.

Zone 27 of Hollowing Run section (1454 A).—Sandy beds, 70 feet thick and apparently barren, follow the last zone.

Zone 28 of Hollowing Run section (1454 A).—Only two species, *Productella* cf. *speciosa* and *Atrypa* cf. *reticularis*, could be recognized in this zone. They are rare.

[a, abundant; c, common; r, rare.]

	Yellow sandstone and shale.		Dark arenaceous shale.		Covered.	Dark sandy shales (Hamilton).				Covered (Genesee?).	Dark bluish-gray arenaceous shales (Sherburne).						Gray or olive-gray arenaceous shale and sandstone (Ithaca member).													
	1	2	3	4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		20	21	22	23	24	25	26	27	28	29
			100 ft.		200 ft.	300 ft.; 400 ft.				500 ft.; 600 ft.; 700 ft.; 800 ft.	900 ft.	1,000 ft.		1,100 ft.; 1,200 ft.			1,300 ft.	1,400 ft.			1,500 ft.	1,600 ft.				1,700 ft.; 1,800 ft.		1,900 ft.		
COELENTERATA.																														
Cladochonus sp												r	c		r		r													
Cystodictya meeki																	c				a		a							
ECHINODERMATA.																														
Crinoid stems															r		c						r							
MOLLUSCOIDEA.																														
Stropheodonta (Leptostrophia) interstrialis												a					a		c		r				c					
Chonetes coronatus							c																							
C. scitulus																	c													
Productella hallana																	r													
Productella speciosa																	c		c				r						r	
Schizophoria striatula															r				a						a		r			
Leiorhynchus mesicostale															a															
Pugnax pugnus																	c						r							
Cryptonella eudora																	r		r											
Tropidoleptus carinatus							c																							
Atrypa reticularis																	c		a		c				c				r	
Cyrtina hamiltonensis																	c		a				r							
Spirifer mesistrialis																	c													
S. pennatus var. posterus																	a		a		a									
S. pennatus							a																							
Reticularia lævis													r																	
MOLLUSCA.																														
Spathella typica																	r				r									
Grammysia subarcuata																	r													
Grammysia sp															r		r													
Buchiola speciosa												c																		
Palæoneilo filosa												r																		
P. plana																	r				r									
P. sp																							r							
Leda diversa													r																	
L. cf. obscura																	r													
Nucula corbuliformis																	r		r											
N. sp															r															
Macrodon hamiltoniæ												r																		
M. sp. nov																					r									
Pterinopecten sp																	c													
Pterinea reproba ?																					r									
Mytilarca carinata																	r													
Actinopteria epsilon																	r													
Schizodus chemungensis var. quadrangularis																	r													
Modiomorpha subalata var. chemungensis															r		r													
M. cf. neglecta															r															
M. subalata																	r													
Pleurotomaria capillaria															r															
Murchisonia sp																	r													
Platyceras cf. conicum																	r													
Tentaculites spiculus																	r													
Coleolus acicula													r				c													
Orthoceras bebryx var. cayuga													r																	
Manticoceras cf. complanatum																	c													
M. sp															r															

Zone 29 of Hollowing Run section (1454 A).—Twenty feet of tough olive sandy shale, apparently barren of fossils, terminate the section.

Exposures cease before the "red beds" are reached. South of Hollowing Run no important outcrops appear until the axis of Little Mountain is passed, when the red Catskill beds, on the south side of the syncline, are seen dipping to the north.

FORMATIONAL CORRELATION OF HOLLOWING RUN SECTION.

By E. M. KINDLE.

The bearing of the detailed paleontological data given in the preceding pages on the correlation of the section may be briefly summed up.

Zones 11 and 12 of the writer's section represent a portion of No. 8 of White's section, which he called the "Genesee shale." These beds have been found to hold a fauna which is distinctively Nunda. The physical characteristics of the beds, which are hard and slaty instead of fissile, confirm the evidence of the fossils and indicate that the lower beds of the section above the concealed interval (No. 9) should be referred to the Nunda formation.

The beds above the Genesee shale of White were referred by him to the Chemung.[a] The supposed discovery of *Spirifer disjunctus* in the section was apparently the reason for this correlation. A careful examination of every part of the section by the writer failed to discover any trace of that species. Since it was reported to occur in great numbers, it could hardly have been overlooked. The fauna which was secured at this horizon has such a distinctly Ithaca character that it is nearly certain that the determination of the form listed as *Sp. disjunctus* by White was an error. The presence of such species as *Sp. pennatus* var. *posterus*, *Productella speciosa*, and *Strophеodonta* (*Leptostrophia*) *interstrialis*, together with the absence of characteristic Chemung species, affords satisfactory and precise data for correlating with the Nunda (Portage) formation, including the Ithaca member, all of this section lying above the Genesee, which appears to belong in the concealed interval.

No very striking differences appear between this section and the Catawissa section. On the contrary, there are some interesting similarities. The comparatively rare forms *Reticularia lævis* and *Pugnax pugnus* are found in both sections. A few recurrent Hamilton species occur in each. *Cyrtina hamiltonensis* is common in both sections. No notable geographical changes in the faunas appear, both sections belonging to the same faunal province.

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[a] Second Pennsylvania Geol. Survey, Rept., G 7, p. 360.

COMMENTS ON THE PALEONTOLOGY OF THE HOLLOWING RUN SECTION.

By H. S. WILLIAMS.

The main fauna, ranging from zone 11 to 28 of this section, presents a general similarity to the fauna in the middle part (zones 10 to 33) of the Catawissa section. If the horizons in which *Reticularia lævis* first occurs be regarded as equivalent in the two sections, the 100-foot portion of the Catawissa section, including zones 21 to 26, is separated from the *Reticularia lævis* zone by something over 300 feet, the corresponding 100-foot portion of the Hollowing Run section contains a typical Ithaca fauna, and the central part of the typical fauna of the Ithaca member lies about the same distance above the conspicuous *Reticularia lævis* zone at the foot of Fall Creek section at Ithaca. It is to be noted that *Productella hallana* occurs with *Pugnax pugnus* in zone 16, as is the case in the typical Ithaca fauna of Ithaca.[a]

This upper fauna of the Hollowing Run section can be thus undoubtedly correlated with the fauna of the Ithaca member of the Nunda (Portage) formation. The association with it of such forms as *Cladochonus*, *Buchiola speciosa*, and *Goniatites* indicate the mingling of species of the typical Nunda sedimentation with the richer Ithaca fauna.

THE LEROY SECTION, BRADFORD COUNTY, PA.

Leroy is in Bradford County, Pa., about 22 miles south of the New York line. It is about midway between the previously described Catawissa section and Ithaca, N. Y., but lies a few miles to the west of a north-south line connecting these points. Four sections in the vicinity of Leroy, which together exhibit nearly all of the outcropping beds to the Pennsylvanian series, have been carefully measured, and taken together are called the Leroy section. These subsections, which will be described separately, are the Gulf Brook, Granville Center, Towanda Narrows, and South Mountain sections.

THE GULF BROOK SECTION.

By E. M. KINDLE.

Gulf Brook enters the valley of Towanda Creek at Leroy, through a post-Glacial gorge which cuts directly across the strike of the Chemung rocks, exposing a section which the State geologist of Pennsylvania has called "the best section of the formation that we have in Pennsylvania."[a]

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[a] Bull. U. S. Geol. Survey No. 3, pp. 18–19.

[b] Summary Final Rept. Second Pennsylvania Geol. Survey, vol. 2, p. 1448.

Mr. A. T. Lilley, of Leroy, published a description of the Gulf Brook section in 1886.[a] Lilley's section was republished by Lesley in 1892.[b] The writer is indebted to Mr. Lilley, who generously assisted in remeasuring and in collecting from the several zones of the section. Beds 63 to 66 of Lilley's section are omitted from the present section, since it is intended to include only those shown in the continuous section of Gulf Brook Gorge. The position of these beds with reference to the rest of the section, moreover, is problematical, since they outcrop in a horizontal position about 2 miles north of the Gulf Brook Gorge, near the axis of the Towanda anticline. The beds of the Leroy section dip to the south at angles varying from a maximum of 60° or more at the south end of the gorge to 5° or 6° at the north end, and expose the following strata:

Section 1455 A at Gulf Brook, Bradford County, Pa.

	Ft.	in.
99. Olive-gray sandy shale	90	0
98. Olive-gray flags	12	0
97. Olive-gray sandy shale	40	0
96. Calcareous gray sandstone	1	0
95. Brownish to olive, thin-bedded sandstone	6	0
94. Olive sandy shale and thin-bedded sandstone	20	0
93. Hard gray flagstone	8	0
92. Olive sandy shale	28	0
91. Reddish and gray sandy beds	10	0
90. Reddish sandy beds	14	0
89. Olive-gray shelly sandstone	12	0
88. Olive-green sandy shale	9	0
87. Gray limestone	0	4
86. Argillaceous green and reddish shale	7	0
85. Hard dark-red and mottled red and green bed	3	0
84. Soft argillaceous red shale	3	0
83. Covered	15	0
82. Hard red sandy beds	5	0
81. Dark-red ferruginous beds	3	6
80. Dark-red to greenish sandy beds	5	0
79. Dark-red low-grade iron ore	3	6
78. Dark-red to purple and gray sandy beds	9	0
77. Greenish shale and hard bluish-gray thin-bedded sandstone	20	0
76. Dark-colored shale with bands of iron ore	4	0
75. Reddish crinoidal limestone	3	0
74. Olive sandy shale	8	6
73. Reddish limestone	10	0
72. Olive-gray sandy shale with calcareous bands	17	0
71. Olive-green shaly sandstone, weathering brown, containing small chalcopyrite crystals	3	0
70. Hard bluish-gray to olive sandstone	20	0
69. Reddish to gray sandstone with limestone bands	4	0
68. Olive-gray shaly sandstone	20	0

[a] Proc. Am. Philos. Soc., vol. 23, pp. 291–293.
[b] Summary Final Rept. Second Pennsylvania Geol. Survey, vol. 2, pp. 1448–1450.

	Ft.	in.
67. Black ferruginous sandstone	5	0
66. Olive-gray sandy shale and shaly sandstone	9	0
65. Dark greenish-purple limestone	4	0
64. Greenish-gray shaly sandstone and shale	15	0
63. Cross-bedded purple limestone	5	0
62. Reddish-brown sandy beds with calcareous band near middle	4	6
61. Olive-gray thin-bedded sandstone, rough-bedded, with occasional dull-brownish beds (top of fall)	27	0
60. Dark-purple sandstone	2	0
59. Gray sandstone	2	0
58. Gray limestone with shell fragments abundant	1	0
57. Grayish-drab shaly sandstone	9	0
56. Dark-purple sandstone	2	0
55. Greenish sandstone	2	0
54. Reddish-brown sandstone with crinoid stems	1	0
53. Shaly olive-gray sandstone	9	0
52. Red highly ferruginous bed with crinoid stems and shell fragments	3	0
51. Dark brownish-purple sandstone with shell fragments and crinoid stems	8	0
50. Tough thin-bedded olive-gray sandstone	13	0
49. Tough thin-bedded olive-gray sandstone	10	0
48. Shaly sandstone and shale with occasional beds of hard sandstone	55	0
47. Tough thin-bedded sandstone and hard sandy shale	5	0
46. Dark-gray to olive-green sandy shale and shaly sandstone	100	0
45. Bluish drab sandy shale with two bands of shaly sandstone 10 inches thick, containing lowest *Spirifer disjunctus*	10	0
44. Grayish-drab sandy shale and shaly sandstone with large concretions near base	65	0
43. Hard sandy drab-colored shale	5	0
42. Shaly grayish-drab sandstone	70	0
41. Hard greenish thin-bedded, ripple-marked sandstone	35	0
40. Grayish-drab shaly sandstone	75	0
39. (Upper part) Drab thin-bedded sandstone and shale	15	0
38. Gray limestone composed of shell fragments	2	0
37. Bluish-drab sandstone and shale	50	0
36. Bluish-gray shale with hard sandstone layers at intervals	15	0
35. Olive-gray shale	6	0
34. Dark sandy shale and shaly sandstone	25	0
33. (Near middle) Dark-gray to bluish shaly sandstone and shale	60	0
32. Dark shale	4	0
31. Tough olive-colored sandstone	2	6
30. Thin-bedded gray sandstone	33	0
29. Dark bluish-gray shale	15	0
28. Bluish shaly sandstone with crinoid stems	4	0
27. Dark bluish-gray sandy shale with bands of sandstone	14	0
26. Grayish-brown fine-grained sandstone	1	8
25. Dark-grayish sandy shale	6	0
24. Bluish-gray limestone	0	6
23. Dark sandy shale and shaly sandstone	8	0
22. Bluish-gray shale and shaly sandstone	9	0
21. Bluish-gray sandy shale	12	0
20. Bluish-gray flags	10	0
19. Covered (to mouth of gorge)	10	0

		Ft.	in.
18.	Dark-gray sandy shale and flags	14	0
17.	Bluish-gray sandy shale	1	3
16.	Hard bluish-gray sandstone	1	6
15.	Dark bluish-gray shale	3	0
14.	Dark bluish-gray sandy shale, partly covered	12	0
13.	Bluish-gray hard sandy limestone	0	9
12.	Olive-gray sandy shale	6	0
11.	Covered (to forks of brook)	60	0
10.	Soft olive-green shale nearly barren of fossils	20	0
9.	Soft olive-green shale	3	0
8.	Hard olive-green sandstone	0	6
7.	Soft olive-green shale, interstratified with harder sandy beds	10	0
6.	Soft olive-green sandy shale	5	0
5.	Covered and sandstone	3	6
4.	Hard flaggy dark-brown sandstone	0	6
3.	Covered	4	0
2.	Hard sandy olive shale	0	6
1.	Soft olive-gray clay shale	1	6

The most important stratigraphical feature of the Gulf Brook section is the belt of limestone bands associated with purple shales and sandstones in the upper part of the section, comprising zones 58 to 75. This limestone belt is a constant feature over most of the western half of Bradford County, where it affords a most important key to the stratigraphy of the region. Sherwood applied the name Burlington limestone to its outcrops on the north side of the Towanda anticline near Burlington.[a] Since this name is preoccupied for a division of the Carboniferous of the Mississippi Valley, it is proposed to substitute the name Franklindale, because the beds are best exposed in the Gulf Brook section west of Franklindale.

Although the section shows no conglomorate horizon, a 6-foot bed of coarse conglomerate caps a hill about a mile west of the section. This conglomerate lies perhaps 300 feet below the Franklindale beds, which outcrop near it.

A band of conglomerate 8 or 10 inches thick outcrops one-third of a mile east of Gulf Brook, which lies a very little higher than the highest zone of that section.

In the road, 1½ miles west of Leroy, is an outcrop of a bed of iron ore which was supposed by Sherwood to be identical with a bed exposed near the top of the Gulf Brook section.[b] Claypole[c] has clearly shown that it lies, as Lilley first pointed out, at a considerably higher horizon, which he estimated at "perhaps 250 feet." The writer's measurements show a thickness of 284 feet of strata in the Gulf Brook section above the highest bed that approaches an ore in composition. The ore in question must therefore lie at Leroy some-

[a] Second Pennsylvania Geol. Survey, Rept. G 37.
[b] Ibid., p. 36.
[c] Proc. Am. Philos. Soc., vol. 20, 1883, p. 530.

where in the concealed interval which separates the Gulf Brook and South Mountain sections, probably 300 feet or more above the ferruginous zone No. 81 of the former section.

FAUNULES OF THE GULF BROOK SECTION.

Zone 1 of Gulf Brook section (1455 A).—The species found in the 18 inches of olive-gray clay shale comprising the lowest zone of this section are as follows:

Faunule of zone 1 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Crinoid stems (r).
2. Chonetes lepidus (r).
3. C. setigerus (c).
4. Productella sp. (r).
5. Camarotœchia cf. eximia (r).
6. Ambocœlia gregaria (c).
7. Edmondia subovata (r).
8. Pholadella radiata (r).
9. Nucula corbuliformis (r).
10. Palæoneilo cf. bisulcata (r).
11. P. cf. elongata (r).
12. Leptodesma spinigerum (r).
13. Cypricardella gregaria (a).
14. Tentaculites bellulus (a).
15. Conularia congregata (r).

Of the 13 species which are specifically identified in this list, 8 have been recorded from the Ithaca fauna. Some of these, as 9 and 10, are recurrent Hamilton species.

Zone 2 of Gulf Brook section (1455 A).—The 6-inch zone following A1 contains the following species:

Faunule of zone 2 of Gulf Brook section (1455 A).

[c, common; r, rare.]

1. Chonetes lepidus (r).
2. Camarotœchia stephani (r).
3. Ambocœlia gregaria (a).
4. Leptodesma spinigerum (r).
5. L. sp. (r).
6. Leiopteria sp. (r).
7. Goniophora chemungensis (c).

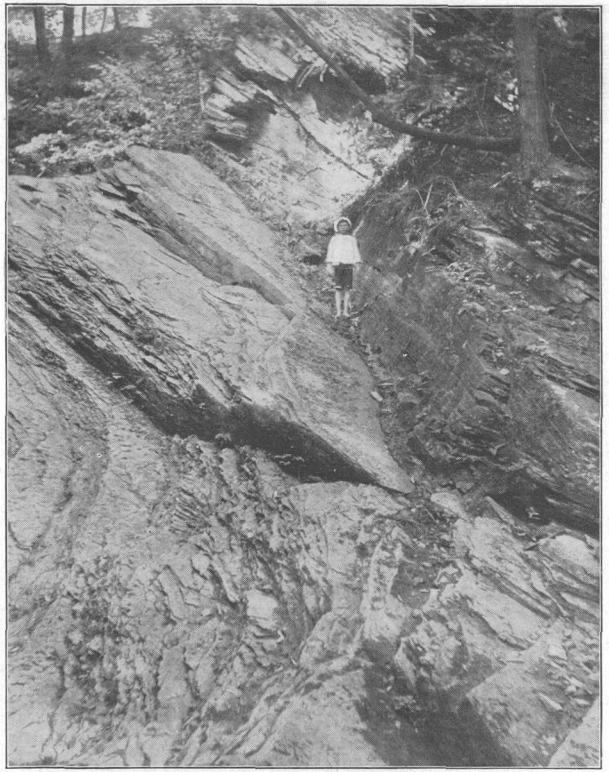
Zone 3 of Gulf Brook section (1455 A).—This zone is concealed.

Zone 4 of Gulf Brook section (1455 A).—The 6 inches of sandstone of this zone holds the following fauna:

Faunule of zone 4 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Chonetes lepidus (r).
2. C. setigerus (c).
3. Ambocœlia gregaria (r).
4. Nucula cf. bellistriata (r).
5. N. corbuliformis (c).
6. Palæoneilo bisulcata var. (c).
7. P. constricta (a).
8. P. perplana (c).
9. P. plana (a).
10. P. cf. tenuistriata (r).
11. Leptodesma spinigerum (c).
12. Schizodus sp. (r).
13. Goniophora chemungensis (r).
14. Cypricardella gregaria (c).



A. LOWEST LIMESTONE OF FRANKLINDALE BEDS.

Part of Gulf Brook section, Pennsylvania.

B. OSWAYO (POCONO) FORMATION.

Zone 12 of South Mountain section, Pennsylvania.

Zone 5 of Gulf Brook section (*1455 A*).—Three and a half inches of beds above zone 4 are concealed.

Zone 6 of Gulf Brook section (*1455 A*).—The 5 inches of soft olive shale of this zone afford the following species:

Faunule of zone 6 of Gulf Brook section (*1455 A*).

1. Lingula sp. (rare).
2. Pholadella radiata (rare).
3. Leptodesma spinigerum (abundant).

The first of these species is extremely abundant, practically excluding other forms. The three individuals of the third species are smaller than specimens figured by Hall. Radiating striæ are absent from one of them.

Zone 7 of Gulf Brook section (*1455 A*).—No fossils were collected from this zone.

Zone 8 of Gulf Brook section (*1455 A*).—This zone affords the following faunule:

Faunule of zone 8 of Gulf Brook section (*1455 A*).

[a, abundant; r, rare.]

1. Stropheodonta (Douvillina) mucronata (r).
2. Delthyris mesicostalis (r).
3. Amboccelia gregaria (a).
4. Goniophora chemungensis (r).

Zone 9 of Gulf Brook section (*1455 A*).—The 3 inches of shale immediately following the last zone contain the following species:

1. Elymella sp. (rare).
2. Sphenotus solenoides (common).
3. Leptodesma spinigerum (rare).

Zones 10 to 12 of Gulf Brook section (*1455 A*).—No fossils were obtained from these three zones.

Zone 13 of Gulf Brook section (*1455 A*).—A 9-inch band of hard sandy limestone contains the following faunule:

Faunule of zone 13 of Gulf Brook section (*1455 A*).

[a, abundant; c, common; r, rare.]

1. Trematopora sp. (c).
2. Chonetes setigerus (c).
3. Delthyris mesicostalis (a).
4. Amboccelia gregaria (a).
5. Leptodesma spinigerum (r).
6. Conularia sp. (r).

D. mesicostalis has a well-developed median septum in the ventral valve.

Zone 14 of Gulf Brook section (*1455 A*).—No fossils were collected from this zone.

Zone 15 of Gulf Brook section (1455 A).—This zone contains the following faunule:

Faunule of zone 15 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Psilophyton sp. (r).
2. Dignomia alveata? (c).
3. Chonetes setigerus (c).
4. Amboccelia gregaria (c).
5. Spathella typica (c).
6. Palæanatina cf. typa (r).
7. Leptodesma sp. (r).
8. Palæoneilo cf. emarginata (r).
9. Cypricardella cf. bellistriata (r).
10. C. tenuis (r).
11. Conularia cf. congregata (r).

Zones 16 to 19 of Gulf Brook section (1455 A).—Fossils are scarce in these zones. No collections were made.

Zone 20 of Gulf Brook section (1455 A).—Ten feet of flaggy sandstone afforded the three following species:

Faunule of zone 20 of Gulf Brook section (1455 A).

1. Productella arctirostrata (rare).
2. Amboccelia gregaria (abundant).
3. Leptodesma sp. (rare).

Zone 21 of Gulf Brook section (1455 A).—This zone contains the following species:

Faunule of zone 21 of Gulf Brook section (1455 A).

1. Productella speciosa (rare).
2. Delthyris mesicostalis (common).
3. Amboccelia gregaria (abundant).

The specimens of *D. mesicostalis* show a double fold on the brachial valve and a plication in the sinus.

Zone 22 of Gulf Brook section (1455 A).—The faunule of this zone includes the following forms:

Faunule of zone 22 of Gulf Brook section (1455 A).

1. Orthothetes cf. chemungensis (rare).
2. Productella speciosa (common).
3. Delthyris mesicostalis (common).

Zone 23 of Gulf Brook section (1455 A).—This zone afforded no fossils.

Zone 24 of Gulf Brook section (1455 A).—A 6-inch band of limestone contains the following faunule:

Faunule of zone 24 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (r).
2. Chonetes sp. (r).
3. Productella speciosa (r).
4. Dalmanella carinata (c).
5. Atrypa spinosa (r).
6. Spirifer mesistrialis.
7. Delthyris mesicostalis (c).
8. Amboccelia gregaria (a).
9. Palæoneilo bisulcata (r).
10. Goniophora cf. chemungensis (r).
11. Orthoceras sp. (r).
12. Dinichthys cf. tuberculatus (c).
13. Onychodus sp. (r).

The occurrence in this zone of *Sp. mesistrialis*, associated with *D. mesicostalis*, is noteworthy since in normal sections the first form precedes the latter, the reverse of the order of their appearance in this section. The two forms have been very seldom found in association.

Zones 25 and 26 of Gulf Brook section (1455 A).—The 26 feet of beds comprising these zones are nearly barren of fossils.

Zone 27 of Gulf Brook section (1455 A).—This zone contains the following species:

Faunule of zone 27 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Strophеodonta (Douvillina) mucronata (r).
2. Chonetes setigerus (a).
3. Spirifer mesistrialis (r).
4. Delthyris mesicostalis (r).
5. Amboccelia gregaria (a).
6. Leptodesma cf. spinigerum (c).

Zone 28 of Gulf Brook section (1455 A).—Crinoid stems are the only fossils recognized in this zone.

Zone 29 of Gulf Brook section (1455 A).—Fossils are scarce at this horizon; the following species occur rarely:

Faunule of zone 29 of Gulf Brook section (1455 A).

1. Crinoid stems.
2. Chonetes setigerus.
3. Camarotœchia sp.
4. Palæoneilo sp.

Zones 30 to *32 of Gulf Brook section (1455 A).*—These beds are nearly barren of fossil remains.

Zone 33 of Gulf Brook section (1455 A).—Fossils are scarce at this horizon, only three species being secured, namely:

Faunule of zone 33 of Gulf Brook section (1455 A).

1. Orthothetes chemungensis (rare).
2. Productella speciosa (common).
3. Delthyris mesicostalis (common).

Zone 34 of Gulf Brook section (1455 A).—Twenty-five feet of barren, thin-bedded sandstone follows the last zone.

Zone 35 of Gulf Brook section (1455 A).—Six feet of gray shale afford the following faunule:

Faunule of zone 35 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (a).
2. Chonetes setigerus (c).
3. Schizophoria striatula (c).
4. Spirifer cf. mesistrialis (r).
5. Delthyris mesicostalis (c).
6. Amboccelia gregaria (c).
7. Palæoneilo sp.
8. Leptodesma spinigerum (c).

Zone 36 of Gulf Brook section (1455 A).—The following species characterize this zone, which is composed of 2 feet of impure limestone composed of shell fragments:

Faunule of zone 36 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Strophеodonta (Leptostrophia) perplana var. nervosa (a).
2. Orthothetes chemungensis (r).
3. Productella speciosa (c).
4. Schizophoria striatula (r).
5. Spirifer mesistrialis (r).
6. Delthyris mesicostalis (c).
7. Orthonota parvula (r).
8. Spathella typica (r).
9. Edmondia cf. subovata (r).
10. Palæoneilo contracta (r).
11. Cypricardella gregaria (r).
12. Tentaculites cf. bellulus (r).

Zone 37 of Gulf Brook section (1455 A).—Fifty feet of barren sandstone beds succeed the last zone.

Zone 38 of Gulf Brook section (1455 A).—This zone contains the following faunule:

Faunule of zone 38 of Gulf Brook section (1455 A).

[a, abundant; r, rare.]

1. Orbiculoidea lodiensis var. media (r).
2. Camarotœchia stephani (a).
3. Sphenotus sp. (r).
4. Spathella sp. (r).
5. Nucula cf. varicosa (r).
6. Nucula sp. (r).
7. Palæoneilo sp. (r).
8. Leptodesma sp. (r).
9. Modiella pygmæa (r).
10. Modiomorpha subalata (r).

Zone 39 of Gulf Brook section (1455 A).—This zone holds the following meager faunule:

Faunule of zone 39 of Gulf Brook section (1455 A).

[a, abundant; c, common,]

1. Strophеodonta (Douvillina) mucronata (a).
2. S. (Leptostrophia) perplana var. nervosa (a).
3. Orthothetes chemungensis (c).
4. Spirifer mesistrialis (a).

Zones 40 to 42 of Gulf Brook section (1455 A).—These zones comprise 180 feet of nearly barren beds.

Zone 43 of Gulf Brook section (1455 A).—The following faunule occurs in 5 feet of sandy shale:

Faunule of zone 43 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Crinoid joints (c).
2. Strophеodonta (Douvillina) mucronata (a).
3. Orthothetes chemungensis (c).
4. Camarotœchia cf. eximia (r).
5. Delthyris mesicostalis (r).
6. Cypricardella gregaria (r).

Mr. H. S. Williams makes the following statement concerning the occurrence of *Camarotœchia* cf. *eximia:*

There begins at zone 43 a fauna presenting some new features. The *Camarotœchia* is reported as *C.* cf. *eximia.* It resembles the form described by Hall as *Rhynchonella contracta* var. *saxatilis* which is said to present valuable characters connecting forms clearly referred to the New York species, *R. contracta,* and to young forms of *R. eximia.* The specimens in the Leroy Brook zone are small in size and resemble young forms of *R. eximia,* but some of the larger sized specimens may be referred to *R. contracta.* In the calcareous beds the smaller sized specimens are abundant. In the shale and ferruginous bands the form called *contracta,* with somewhat coarser and fewer plication and more abrupt and decided fold and sinus appears.

Zone 44 of Gulf Brook section (*1455 A*).—Sixty-five feet of barren beds follow the zone 43.

Zone 45 of Gulf Brook section (*1455 A*).—This zone contains the following species:

Faunule of zone 45 of Gulf Brook section (*1455 A*).

1. Camarotœchia cf. eximia (abundant).
2. Spirifer disjunctus (abundant).
3. Dipterus sp. (rare).

This faunule is interesting, because *Sp. disjunctus* makes its first appearance in the section at this horizon.

Zone 46 of Gulf Brook section (*1455 A*).—Zone 45 is followed by 100 feet of nearly barren beds.

Zone 47 of Gulf Brook section (*1455 A*).—Only one species, *Spirifer disjunctus,* was found at this horizon.

Zone 48 of Gulf Brook section (*1455 A*).—This zone is composed of 55 feet of barren sandy beds.

Zone 49 of Gulf Brook section (*1455 A*).—Resting on the preceding zone are 10 feet of thin-bedded sandstones containing the following species:

Faunule of zone 49 of Gulf Brook section (*1455 A*).

1. Camarotœchia cf. eximia (rare).
2. Spirifer disjunctus (rare).
3. Leptodesma sp. (rare).

Zones 50 to 59 of Gulf Brook section (*1455 A*).—These zones include the lowest "red beds" of the section, which are dull red to purplish rather than red. The fossils occuring in them are mostly fragmentary in character.

Zone 60 of Gulf Brook section (*1455 A*).—The 2 feet of dark purple sandstone of this zone contain *Camarotœchia* cf. *eximia* and *Spirifer disjunctus.* Both species are abundant.

Zone 61 of Gulf Brook section (1455 A).—Twenty-seven feet of thin-bedded sandstone with very few fossils extend from the last zone to the top of the first waterfall.

Zone 62 of Gulf Brook section (1455 A).—This zone, which lies at the top of the fall, contains *Camarotœchia* cf. *eximia* and *Spirifer disjunctus*. Both forms are common.

Zone 63 of Gulf Brook section (1455 A).—This zone includes 5 feet of cross-bedded purple limestone lying near the top of the fall. *Camarotœchia* cf. *eximia* is abundant and *Spirifer disjunctus* is common.

Zones 64 to 68 of Gulf Brook section (1455 A).—These zones contain comparatively few fossils.

Zone 69 of Gulf Brook section (1455 A).—Four feet of reddish limestone at the foot of the falls contain the following species:

Faunule of zone 69 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Camarotœchia cf. eximia (a).
2. Cryptonella cf. eudora (a).
3. Spirifer disjunctus (c).
4. Modiomorpha sp. (r).

The *Cryptonella eudora* noted here is a much larger variety than that occurring in the Ithaca fauna; otherwise the two appear to be identical.

Zones 70 to 72 of Gulf Brook section (1455 A).—No collections were made from these zones. Fossils are scarce in them.

Zone 73 of Gulf Brook section (1455 A).—Ten feet of reddish limestone near the lower end of the gorge contain the following fossils:

Faunule of zone 73 of Gulf Brook section (1455 A).

1. Fistulipora sp. (rare).
2. Camarotœchia cf. eximia (common).
3. Cryptonella eudora var. (rare).
4. Spirifer disjunctus (abundant).

The specimens of *Sp. disjunctus* are large, squarish, slightly convex shells with a wide, shallow sinus and slightly elevated fold.

Zones 74 to 77 of Gulf Brook section (1455 A).—These zones, which aggregate a thickness of 35 feet 6 inches, outcrop in a field a few rods east of the gorge. They contain at this point an abundant fish fauna, embracing the following species:

Faunule of zones 74 to 77 of Gulf Brook section (1455 A).

1. Holonema rugosa.
2. Bothriolepis minor.
3. Holoptychius filosus.
4. Coccosteus macromus.

The fishes listed from this zone were collected by Mr. A. T. Lilley and identified and described by Cope.[a] The fish remains are most

[a] On some new and little known Paleozoic vertebrates: Proc. Am. Philos. Soc., vol. 30, 1892, pp. 221-228.

easily secured from the outcrop of the limestone in a field a few rods east of the brook.

Zone 78 of Gulf Brook section (*1455 A*).—Above the fish beds are 9 feet of purplish beds, from which no fossils were secured.

Zone 79 of Gulf Brook section (*1455 A*).—An arenaceous impure iron ore contains the following faunule:

Faunule of zone 79 of Gulf Brook section (*1455 A*).

[a, abundant; r, rare.]

1. Orthothetes chemungensis (r).
2. Camarotœchia cf. eximia (a).
3. Cryptonella cf. eudora (a).
4. Spirifer disjunctus (a).

The *Cryptonellas* are of very large size, as in the preceding zones.

Zones 80 to 86 of Gulf Brook section (*1455 A*).—These zones contain very few fossils.

Zone 87 of Gulf Brook section (*1455 A*).—Four inches of gray limestone hold the following faunule:

Faunule of zone 87 of Gulf Brook section (*1455 A*).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (c).
2. Camarotœchia cf. eximia (r).
3. Cryptonella eudora var. (a).
4. Spirifer disjunctus (a).

The shells of No. 4 have a high area, deep sinus, and prominent fold, the general contour of the shell presenting a strong contrast to the type of shell occurring in zone 73. The shells of *O. chemungensis* are all small, none exceeding one-half inch in length.

Zone 88 of Gulf Brook section (*1455 A*).—Nine feet of barren shale follow the last zone.

Zone 89 of Gulf Brook section (*1455 A*).—This zone contains the following faunule:

Faunule of zone 89 of Gulf Brook section (*1455 A*).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (r).
2. S. (Leptostrophia) perplana var. nervosa (r).
3. Orthothetes chemungensis (c).
4. Schizophoria striatula (c).
5. Camarotœchia cf. eximia (c).
6. Atrypa spinosa (a).
7. Spirifer disjunctus (r).
8. Sphenotus sp. (r).
9. Dipterus (Ctenodus) cf. flabelliformis (r).

Zones 90 to 95 of Gulf Brook section (*1455 A*).—These zones contain few fossils. No collections were made from them.

Zone 96 of Gulf Brook section (1455 A).—This zone, comprising 1 foot of fossiliferous sandstone, contains the following faunule:

Faunule of zone 96 of Gulf Brook section (1455 A).

[a, abundant; c, common; r, rare.]

1. Aulopora sp. (r).
2. Orthothetes chemungensis (a).
3. Atrypa spinosa (r).
4. Spirifer disjunctus (c).
5. Leptodesma sp. (r).

This is the highest fossiliferous zone of the section. The beds following it, which extend to the lower end of the gorge, appear to be entirely barren.

GRANVILLE CENTER SECTION.

By H. S. WILLIAMS.

One-half mile south of Granville Center 35 or 40 feet of gray, sandy shales and sandstone outcrop near the brow of the hill just west of the highway. This outcrop lies near the axis of the anticline and shows no dip. This locality is about 2 miles north of the Gulf Brook section, and the beds represent a horizon somewhere near the base of that section. The faunule which they contain includes the following species:

Faunule of Granville Center section (1455 B).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (r).
2. Chonetes scitulus (a).
3. Productella speciosa (r).
4. Dalmanella tioga (c).
5. Leiorhynchus sinuatum (c).
6. Cryptonella sp. (c).
7. Atrypa aspera (c).
8. A. reticularis (c).
9. Spirifer mesistrialis (r).
10. Delthyris mesicostalis (a).
11. Amboccelia gregaria (c).
12. Edmondia philipi (r).
13. E. subovata (r).
14. Nucula corbuliformis (r).
15. Palæoneilo plana (r).
16. Leptodesma lichas (a).
17. L. potens (c).
18. Leiopteria cf. sayi (a).
19. Pterinopecten vertumnus (r).
20. Goniophora chemungensis (c).
21. Cypricardella gregaria (c).
22. Bellerophon (Ptomatis?) rudis (c).
23. Pleurotomaria (Clathrospira?) capillaria (a).
24. Tentaculites cf. bellulus (a).
25. Manticoceras patersoni (r).

The presence in this fauna of such Hamilton species as *Cypricardella gregaria*, *Nucula corbuliformis*, *Pterinopecten vertumnus*, and other species having close affinities to, if not identical with, Hamilton species is worthy of note. The general character of the fauna, however, indicates an horizon near the boundary between the Nunda and the Chemung faunas, but above the base of the Chemung formation. It contains six of the fifteen diagnostic Chemung species named on p. 57.

Faunal chart of sections at Gulf Brook and Leroy, Bradford County, Pa.

[a, abundant; c, common; r, rare.]

	Olive-gray shale.				Dark bluish-gray shale and sandstone																	Gray limestone.	Drab-colored sandstone and shale.										Dull reddish or purple sandstone and shale with limestone bands (Franklindale beds).														Reddish and gray colored sandstone and shales.										Olive-gray thin-bedded sandstone and shale.				
	1–6.	7.	8–10.	11.	12–14.	15–18.	19.	20.	21.	22.	23.	24–26.	27.	28.	29.	30.	31–32.	33.	34.	35.	36.	37.	38–39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51–52.	53.	54–60.	61.	62.	63.	64.	65–67.	68.	69.	70.	71–73.	74–76.	77.	78.	79–82.	83.	84–87.	88–89.	90.	91.	92.	93.	94–96.	97.	98.	99.
				100 ft.							200 ft.							300 ft.				400 ft.		500 ft.		600 ft.		700 ft.		800 ft.					900 ft.							1,000 ft.						1,100 ft.						1,200 ft.							1,300 ft.
COELENTERATA.																																																													
Aulopora sp																																																										r			
Trematopora sp					c																																																								
Fistulipora sp																																														r															
ECHINODERMATA.																																																													
Crinoid stems	c														r													c																																	
MOLLUSCOIDEA.																																																													
Lingula sp.	r																																																												
Dignomia alveata ?						c																																																							
Orbiculoidea lodensis var. media																							r																																						
Stropheodonta (Douvillina) mucronata			r										r										a					a																									r								
S. (Leptostrophia) perplana var. nervosa																					a		a																														r								
Orthothetes chemungensis								r		r		r						r		a	r		c					c																					r			c	c					a			
Chonetes lepidus	r																																																												
C. setigerus	c				c	c							a		r					c																																									
C. sp								r																																																					
Productella arctirostrata								r																																																					
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Camarotœchia cf. eximia	r																											r	a			a					a		c	c						a			a			r	c								
C. stephani	r																						a																																						
C. sp															r																																														
Cryptonella cf. eudora																																														a			a												
C. eudora var.																																															r					a									
Atrypa spinosa												r																																									a					r			
A. reticularis																																																													
Spirifer disjunctus																													a	r		r					a		c	a						c	a		a			a	?					c			
Delthyris mesicostalis			r		a			c		c		c	r					c		c	c							r																																	
Spirifer mesistrialis												r	r							r	r		a																																						
Ambocœlia gregaria	a		a		a	c		a				a	a							c																																									
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Leiopteria sp	r																																																												
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M. sp																																														r															
Goniophora chemungensis	c		r									r																																																	
Palæanatina cf. typa						r																																																							
Spathella typica						c														r																																									
Sphenotus solenoides			c																																																										
S. sp																							r																														r								
Sphathella sp																							r																																						
Modiella pygmæa																							r																																						
Pholadella radiata	r																																																												
Cypricardella cf. bellistriata						r																																																							
C. gregaria	a																				r					r																																			
C. tenuis						r																																																							
Tentaculites cf. bellulus																					r																																								
T. bellulus	a																																																												
Conularia congregata	r					r																																																							
C. sp					r																																																									
Orthoceras sp												r																																																	
PISCES.																																																													
Bothriolepis minor Newb																																																r													
Coccosteus macromus Cope																																																r													
Dinichthys tuberculatus?												c																																																	
Dipterus (Ctenodus) cf. flabelliformis																													r																								r								
D. sp																																																													
Holonema rugosa Clayp																																																r													
(?) Holoptichius filosus Cope																																																r													
Onychodus sp												r																																																
PLANTÆ.																																																													
Psilophyton sp						r																																																							

Bull. 244—05. (To face page 104.)

SOUTH MOUNTAIN SECTION.

By E. M. KINDLE.

A small ravine descending from the summit of South Mountain, opposite Leroy, exposes a section directly across Towanda Creek Valley, opposite the Gulf Brook section. The alluvium of the valley conceals about 450 feet of beds lying between the top of the Gulf Brook and the base of the South Mountain sections. About 300 feet of these concealed beds are exposed in the Towanda Narrows section. The South Mountain section continues the exposures of the previously described sections up to the Barclay coal bed. South Mountain is a synclinal mountain, and the strata on the north face, where this section was taken, have a very small dip to the south, the maximum being 10° at the base of the section.

The section is as follows:

Section 1455 C, at South Mountain, Bradford County, Pa.

	Feet.
31. Hard, massive, white to gray coarse sandstone, locally conglomeratic (outcropping on south brow of mountain)	20
30. Covered (estimated)	100
29. Thin-bedded gray sandstone	6
28. Covered	8
27. Shaly gray sandstone	15
26. Gray calcareous sandstone with carbonate of iron concretions and clay fragments scattered throughout	3
25. Grayish-green flags	4
24. Red and green shale	15
23. Red shale	10
22. Green thin-bedded sandstone	40
21. Red shale	28
20. Green sandstone	1
19. Red shale	5
18. Green thin-bedded sandstone	55
17. Red shale	12
16. Green to gray flaggy sandstone	15
15. Red shale	8
14. Green sandstone	3
13. Red shale	5
12. Flaggy green sandstone	105
11. Red shale	6
10. Flaggy green micaceous sandstone	110
9. Thin-bedded red and green sandstone	188
8. Reddish sandstone with fish remains	1
7. Thin-bedded red and green sandstone	72
6. Thin-bedded red sandstone (exposed in series of cascades)	115
6. Fish bed[a]	2
5. Thin-bedded red sandstone	35
4. Shaly red sandstone	25

[a] The fish bed, No. 6, was not seen in the section, but outcrops 300 yards to the west on the Rose Holcombe land.

	Feet.
3. Red shale	15
2. Shaly red sandstone with traces of plants	10
1. Covered from the level of Towanda Creek	150
Total	1,111

About 3 miles west of the South Mountain section 30 feet or more of dark-red shale outcrops in the Cold Spring road near the summit of the north face of the mountain. This shale probably belongs in the partly covered zones Nos. 28–30 of the above section and represents apparently the Mauch Chunk formation.

The peculiar calcareous bed, No. 26 of the section, agrees in its lithologic characters and horizon with a somewhat thicker bed of siliceous limestone in the Armenia Mountain and Tioga sections, viz, 1458 B59, called the Armenia limestone lentil of the Oswayo formation (see 127).

FAUNA OF SOUTH MOUNTAIN SECTION.

Careful search failed to discover any invertebrate fossils in the beds of this section. Fish remains, however, occur in abundance in at least two horizons. In zone 6, about 16 inches of the bed consist largely of a mass of the plates of *Bothriolepis leidyi*. Fragments of fish plates, probably *B. leidyi*, occur also in zone 8, 425 feet above the base of the section. Above this no traces of animal remains were found.

TOWANDA NARROWS SECTION.

By E. M. KINDLE.

At the "Narrows," about 1 mile below Franklindale post-office, Towanda Creek has exposed a series of beds lying somewhat higher than those which terminate the Gulf Brook section. The beds have a southerly dip which increases rapidly toward the north. The outcrops continue back to the limestone horizon of the Franklindale beds, along a small brook which joins Towanda Creek just above the "Narrows." This limestone of the Franklindale beds affords a good stratigraphic basis for the comparison of the two sections. Comparing the beds in the two sections, which lie above this horizon, it is seen that the Towanda Narrows section extends more than 300 feet above the top of Gulf Brook section. The following section begins with the lowest outcrops near the point where the highway crosses a small brook, one-third of a mile north of the "Narrows."

Section 1456 A, at Towanda Narrows.

	Ft.	in.
40. Soft olive-green shale	10	0
39. Dull brownish-red sandstone	15	0
38. Olive-gray to purple micaceous thin-bedded sandstone	10	0
37. Red shale	3	0
36. Reddish-brown sandstone	1	8
35. Red and green shale	15	0

	Ft.	in.
34. Red to greenish sandstone and shale	6	0
33. Olive-gray micaceous sandstone, weathering brownish	25	0
32. Soft greenish sandy shale	6	0
31. Covered	65	0
30. Olive-gray sandy shale	12	0
29. Soft olive-gray shale	10	0
28. Massive olive-brownish sandstone with large concretions at base	5	0
27. Reddish sandstone and olive-gray shale interbedded	25	0
26. Olive-gray sandy shale	28	0
25. Dark reddish-brown, thin-bedded sandstone with some thin layers of greenish gray shale (dip 12° S.)	40	0
24. Covered	65	0
23. Bluish-gray flags (end of gorge, dip 25° S.)	100	0
22. Olive-gray thin-bedded sandstone	190	0
21. Olive-gray to reddish shales	40	0
20. Gray to reddish limestone	4	0
19. Red sandy shale	4	0
18. Calcareous hard red sandstone	2	0
17. Gray to purple limestone	4	6
16. Hard olive-gray sandstone (dip 60° S.)	15	0
15. Dark red, rather soft shale	12	0
14. Olive-gray sandy beds	10	0
13. Covered	6	0
12. Gray sandstone	1	0
11. Red shaly sandstone	3	0
10. Gray to reddish thin-bedded sandstone	30	0
9. Dark-red sandstone	3	0
8. Bluish-gray fossiliferous limestone	1	0
7. Covered	4	0
6. Bluish-gray sandstone, with *Sp. disjunctus*, etc	4	0
5. Dark red-brown sandstone	3	6
4. Gray shale	0	6
3. Dark reddish-brown sandstone with much iron	3	0
2. Covered	18	0
1. Gray sandy flags	15	0
	815	2

FAUNA OF TOWANDA NARROWS SECTION.

Many zones of this section contain an abundance of fossils, but lack of time prevented a detailed study of them. Fossils were collected from but one zone, the highest in the section, which affords the following faunule:

Faunule of zone 40 of Towanda Narrows section (1456 A).

[a, abundant; c, common; r, rare.]

1. Orbiculoidea lodiensis var. media (r).
2. Orthothetes chemungensis (r).
3. Productella lachrymosa (a).
4. Schizophoria striatula (c).
5. Camarotœchia stephani (a).
6. Cryptonella eudora (r).
7. Atrypa reticularis (r).
8. Delthyris mesicostalis (r).
9. Spirifer disjunctus (a).
10. Sphenotus sp. (r).
11. Leptodesma sp. (r).

The fauna is chiefly of interest as showing the presence of a Chemung fauna after sediments of strongly Catskill type have made their appearance in the section.

FORMATIONAL CORRELATION OF LEROY SECTION.

By E. M. KINDLE.

The sections which have been described from exposures in the vicinity of Leroy give a connected section from the Sharon conglomerate down to the lowest beds exposed in the Towanda anticline, aggregating a thickness of 2,902 feet. The section may be divided, with reference to its more prominent lithological characteristics, into the following divisions:

General divisions of the Leroy section.

	Feet.
7. Coarse gray or white sandstone conglomerate (Sharon conglomerate)	20
6. Soft red shales (Mauch Chunk)	30
5. Red and greenish sandstones and shales, green beds predominating (Oswayo)	712
4. Red and green sandstones and shales, the red beds predominating (Cattaraugus or Catskill)	653
3. Drab-colored shales and sandstone with some highly ferruginous bands (Chemung)	400
2. Purple or reddish sandstone and shale interbedded with heavy beds of limestone (Franklindale beds)	160
1. Gray arenaceous shales and thin bedded sandstones (Chemung)	927
	2,902

There is nothing in the uninterrupted sequence of sandy shales and sandstones which make up the first 900 feet of the section to lead to any sudden change in the faunas. We may therefore expect to find, as we do in this section, that many representatives of the Ithaca fauna have continued on for some time after the appearance of Chemung types. The Ithaca fauna is an indigenous fauna in eastern New York, having been derived chiefly from the Hamilton. The Chemung represents a later development of the same fauna with the addition of certain foreign forms, as *Spirifer disjunctus*. This species first appears in the section about 700 feet above the base. *Delthyris mesicostalis*, which is a characteristic Chemung form, appears near the base of the section. The Ithaca element of the fauna is seen in the presence of such forms as *Sp. mesistrialis*, which indicates an overlapping of the Chemung and Ithaca faunas. The appearance near the base of the section of a form of so much zonal significance as *Delthyris mesicostalis* with well-developed medial septum seems to justify the correlation of the lowest division of the section with the Chemung. The Ithaca species which have transgressed the normal upper limit of that fauna nearly all disappear in the first 500 feet of the section.

The Chemung fauna continues for 800 feet above the lowest reddish beds. Its highest appearance is in beds which lithologically are of a decided Catskill type. Catskill fishes are found in the red shales after the Chemung fauna has entirely disappeared. These remains, however, do not continue to the upper limit of the Catskill type of sediments.

After the disappearance of Devonian fossils from the Leroy section the beds are entirely barren, so that there are no paleontological data for drawing the line between the Devonian and Carboniferous. In the absence of definite paleontological evidence the Devono-Carboniferous line may be drawn tentatively between divisions four and five of the generalized section, which corresponds to the base of the Oswayo—the Pocono of the Pennsylvania survey. The evidence of sections farther west, to be described later, seems to favor this correlation.

COMMENTS ON CORRELATION OF THE LEROY SECTION.

By H. S. Williams.

The first zone paleontologically includes the faunules 1 to 6 with *Pholadella radiata* and recalls the early stage of the Chemung as it appears in the Ithaca and Waverly quadrangles of New York, with a recurrent Hamilton fauna, and before the Chemung fauna is represented in full force.

From 7 up to 39 inclusive is a zone holding the *Stropheodonta* (*Douvillina*) *mucronata* fauna with *Delthyris mesicostalis*, *Spirifer mesistrialis*, and *Dalmanella carinata*, but without *Spirifer disjunctus;* while above, from faunule 43 to the top, *Spirifer disjunctus* occurs abundantly in almost all the fossiliferous zones, but the other spirifers are wanting and the pelecypods are rare compared with their frequent appearance in the lower zone.

It is probable that the first zone, including the lower 600 feet of this section, represents the fossiliferous zone which was called "Lower Chemung fauna" in 1884,[a] while the second zone represents the "typical Chemung" of that classification and the 1,100 feet of sediment may carry the strata up as high or higher than the horizon where the red Catskill type of sedimentation first appears in the Bradford County section at Ulster.[b]

The prominence of the calcareous beds, the dominance of *Cryptonella* in some zones, and the fish fauna are conspicuous features of this upper zone.

[a] Trans. Am. Inst. Min. Eng., vol. 16, p. 946. Also quoted in Doctor Kindle's paper on the Relation of the fauna of the Ithaca group to the faunas of the Portage and Chemung, Bull. Am. Paleontology, vol. 2, 1896, p. 9.

[b] On the fossil faunas of the upper Devonian along the meridian of 76° 30′ from Tompkins County, N. Y., to Bradford County, Pa: Bull. U. S. Geol. Survey No. 3, p. 27.

It is to be noted that in the one continuous section of Gulf Brook the Chemung fauna has a range of 1,200 feet. If the correlation of the Towanda Narrows section with its upper part be correct, the range is extended 300 feet higher. The estimate of the length of this range, made on the basis of the section along the 76° 30′ meridian, was 1,200 feet; but at that time (1884) the upper limit of the Chemung was put where the red beds first appear in force. It is now known that the Chemung fauna does not everywhere stop at that horizon. It is, however, quite probable that the Leroy section covers the greater part of the total range of the Chemung fauna for that region, which by measurement is 1,700 feet of strata.

THE TIOGA SECTION.

By E. M. KINDLE.

Tioga River cuts squarely across the axis of the Crooked Creek synclinal mountain, just south of the village of Tioga. North of the town, the southward-dipping Chemung beds are well exposed on the east bank of the river. The following section is based upon the outcrops between the wagon bridge, two-thirds of a mile north of the town, and the Pennsylvania Railroad station, and on those in and near the highway between Tioga and the summit of the mountain, 4 miles east of Tioga:

Section 1460 A, at Tioga, Pa.

		Feet.
56.	White coarse sandstone with numerous small angular quartz pebbles	20±
[a]55.	Black carbonaceous shale	1±
54.	Coal ? (a few inches reported)	?
53.	Covered (place of Mauch Chunk)	45±
52.	Mottled arenaceous gray limestone with lumps of shale and fish teeth	10
51.	Covered	10±
50.	Irregular-bedded coarse buff sandstone, some layers with numerous carbonized plants	10
49.	Covered	10
48.	Red shale	10
47.	Light-green thin-bedded micaceous sandstone	45
46.	Greenish-gray and red sandstone and shales mostly covered. (Oswayo and Cattaraugus)	960±
45.	Red and gray beds mostly concealed. (Cattaraugus-Chemung transition)	100
44.	Gray thin-bedded sandstone	5
43.	Covered	15
42.	Drab-colored thin-bedded sandstone (partly concealed)	16
41.	Covered	4
40.	Thin-bedded drab sandstone	12
39.	Thin-bedded drab sandstone	16
38.	Covered	32

[a] Nos. 47 to 55 of the section are exposed in a shaft, drift, and quarry near the residence of A. H. Rawson.

	Feet.
37. Gray to reddish thin-bedded sandstone	25
36. Covered	12
35. Red highly ferruginous sandstone	2
34. Dull-reddish to olive shale and sandstone	13
33. Bed of *Sp. disjunctus* shells	2
32. Olive-gray sandstone	5
31. Covered	5
30. Dull-reddish shale and thin-bedded sandstone	40
29. Thin-bedded gray sandstone	20
28. Olive-gray shale with thin bands of sandstone	30
27. Gray to salmon-brown thin-bedded sandstone with concretionary structure	25
26. Dark-gray shale and shaly sandstone	20
25. Covered	6
24. Dull-reddish shale and sandstone with fossiliferous band	4
23. Covered	5
22. Dull-reddish to gray shale	18
21. Dark-reddish thin-bedded sandstone	15
20. Dull salmon-brown to olive shale	10
19. Olive-gray shale and thin-bedded sandstone, some of beds with dull-reddish tint	30
18. Olive-gray and dull-reddish shale	20
17. Covered	10
16. Olive-gray and dull-reddish thin-bedded sandstone interbedded	18
15. Covered	5
14. Thin-bedded sandstone	4
13. Gray to reddish shale and sandstone	9
12. Calcareous bed of fossils	2
11. Gray sandstone	3
10. Beds of fossil shells in drab calcareous sandstone	3
9. Dull-brownish red thin-bedded sandstone	3
8. Sandstone and shale with concretions	4
7. Gray sandstone	4
6. Gray shale and sandstone	5
5. Soft gray clay shale	10
4. Covered	35
3. Thin-bedded drab sandstone	14
2. Covered	15
1. Brownish-gray thin-bedded sandstone	20
	2,315

FAUNULES OF THE TIOGA SECTION.

Zone 1 of Tioga section (1460 A).—The 20 feet of sandstone exposed at the bridge, two-thirds of a mile north of Tioga, contains the following species:

Faunule of zone 1 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) inæquistriata (c).
2. S. (Leptostrophia) perplana var. nervosa (a).
3. Strophonella cælata (a).
4. Chonetes cf. vicinus (c).
5. Atrypa reticularis (r).
6. A. spinosa (c).
7. Sphenotus cf. archæformis (r).
8. Macrodon cf. chemungensis (r).
9. Leptodesma lichas (a).
10. Schizodus chemungensis (r).
11. S. oblatus (r).
12. Modiomorpha cf. quadrula (r).
13. Manticoceras cf. complanatum (r).

The Chemung characteristics of this faunule, which is the lowest in the section, indicate that the section includes nothing lower than Chemung beds.

Zone 7 of Tioga section (1460 A).—Very few fossils occur in the zones 2 to 6. The following species are found in zone 7, 100 feet above the base of the section:

Faunule of zone 7 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (a).
2. Orthothetes chemungensis (r).
3. Atrypa spinosa (c).
4. Spirifer disjunctus (r).

Zones 8 and 9 of Tioga section (1460 A).—These zones appear to be without fossils.

Zone 10 of Tioga section (1460 A).—The species noted in this zone are as follows:

Faunule of zone 10 of Tioga section (1460 A).

[a, abundant; c, common.]

1. Stropheodonta (Douvillina) mucronata (c).
2. Atrypa spinosa (c).
3. Spirifer disjunctus (a).
4. Fish remains (c).

The extremely mucronate form of *Sp. disjunctus* is found in this zone.

Zone 12 of Tioga section (1460 A).—This zone contains a mass of fossils, mostly shells of *Sp. disjunctus.*

Zones 13 to 15 of Tioga section (1460 A).—Fossils are comparatively scarce in these zones.

Zone 16 of Tioga section.—The faunule of this zone comprises the following species:

Faunule of zone 16 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Strophonella cælata.
2. Orthothetes chemungensis.
3. Productella cf. lachrymosa (c).
4. Schizophoria striatula (a).
5. Spirifer disjunctus (a).
6. Glossites lingualis (r).
7. Palæoneilo filosa (r).
8. Platyceras sp. (r).

Zone 18 of Tioga section (1460 A).—This zone affords the following species:

Faunule of zone 18 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (r).
2. Strophonella cælata (c).
3. Orthothetes chemungensis (r).
4. Productella lachrymosa (a).
5. Schizophoria striatula (a).
6. Atrypa spinosa (r).
7. Cyrtina hamiltonensis (r).
8. Spirifer disjunctus (a).
9. Leptodesma lichas (c).
10. L. sp. (r).
11. Bellerophon sp. (r).

Zone 24 of Tioga section (1460 A).—The 80 feet of beds intervening between zones 18 and 24 contain few fossils, the species being forms common to these two zones. The species occurring in zone 24 are as follows:

Faunule of zone 24 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Zaphrentis sp. (r).
2. Stropheodonta (Douvillina) mucronata (r).
3. S. sp. (a).
4. Strophonella cælata (r).
5. Orthothetes chemungensis (r).
6. Productella sp. (r).
7. Spirifer disjunctus (a).

Zone 29 of Tioga section (1460 A).—The species occurring in this zone are as follows:

Faunule of zone 29 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (c).
2. Chonetes setigerus (r).
3. Productella lachrymosa (a).
4. Schizophoria striatula (c).
5. Dalmanella tioga (r).
6. Camarotœchia stephani (c).
7. Spirifer disjunctus (a).
8. Delthyris mesicostalis (a).
9. Glossites lingualis (r).

Zone 33 of Tioga section (1460 A).—A mass of the shells of *Sp. disjunctus* comprises the greater part of this zone. The species recognized in it are as follows:

Faunule of zone 33 of Tioga section (1460 A).

1. Productella lachrymosa (rare).
2. Camarotœchia stephani (rare).
3. Spirifer disjunctus (abundant).

Zone 34 of Tioga section (1460 A).—Only three species were recognized in this zone.

Faunule of zone 34 of Tioga section (1460 A).

1. Orthothetes chemungensis (common).
2. Spirifer disjunctus (common).
3. Orthoceras sp. (rare).

Zone 35 of Tioga section (1460 A).—Two feet of very ferruginous red sandstone hold the following faunule:

Faunule of zone 35 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (r).
2. Camarotœchia sp. (r.)
3. Spirifer disjunctus (a).
4. Delthyris mesicostalis (r).
5. Amboccelia gregaria (c).
6. Athyris cf. angelica (r).
7. Mytilarca chemungensis (r).
8. Aviculopecten duplicatus (r).
9. A. striatus (r).

Zone 39 of Tioga section (1460 A).—Seventy feet above the preceding faunule the following association of species occurs:

Faunule of zone 39 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Productella lachrymosa (a).
2. Schizophoria striatula (c).
3. Camarotœchia stephani (c).
4. Delthyris mesicostalis (c).
5. Amboccelia gregaria (c).
6. Athyris angelica (r).
7. Aviculopecten cf. cancellatus (r).

Zone 42 of Tioga section (1460 A).—This zone, nearly 600 feet above the base of the section, contains nearly the same association of species as the preceding faunule, 39, 60 feet below it. The species are as follows:

Faunule of zone 42 of Tioga section (1460 A).

[c, common; r, rare.]

1. Orthothetes chemungensis (c).
2. Productella lachrymosa (r).
3. Schizophoria striatula (c).
4. Camarotœchia stephani (r).
5. Delthyris mesicostalis (c).
6. Amboccelia gregaria (c).
7. Athyris angelica (c).
8. Sphenotus sp. (r).

Zone 44 of Tioga section (1460 A).—Fifteen feet above zone 39 occurs the highest faunule secured from the section. It contains the following species:

Faunule of zone 44 of Tioga section (1460 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta sp. (r).
2. Productella lachrymosa (a).
3. Schizophoria striatula (a).
4. Camarotœchia stephani (c).
5. Leiorhynchus mesicostale (r).
6. Atrypa reticularis (r).
7. Spirifer disjunctus (c).
8. Delthyris mesicostalis (c).
9. Amboccelia gregaria (c).
10. Athyris angelica (c).
11. Sphenotus contractus (r).
12. Glossites procerus (r).
13. Mytilarca chemungensis (c).
14. Actinopteria sp. (r).

The beds immediately following this zone are concealed, and the Chemung fauna may continue on through 50 feet or more of the gray or reddish beds succeeding it. After the typical red Catskill beds are reached, however, no trace of fossils appears beyond some obscure plant remains.

The accompanying chart exhibits the range of the several species comprising the fauna of this section.

Faunal chart of the Tioga section (1460 A), Tioga County, Pa.

[a, abundant; c, common; r, rare.]

	Gray shales and sandstone (Chemung).								Gray and dull-reddish sandstone and shales (Chemung).																						
	1.	2.	3.	4.	5.	6–10.			16.	17.	18.	19.	20.	21.	22–24.	25–26.	27.	28.	29.	30.		31.	32–36.	37.	38.	39.	40.	41.	42.	43.	44.
					100 ft.					200 ft.						300 ft.				400 ft.					500 ft.					600 ft.	
COELENTERATA.																															
Zaphrentis sp														r																	
MOLLUSCOIDEA.																															
Stropheodonta (Douvillina) mucronata, Conrad					a	c				r				r																	
S. (Douvillina) inequistriata	c																														
S. (Leptostrophia) perplana var. nervosa	a																														
Stropheodonta sp														r																	r
Strophonella cælata	a								c	c				r																	
Orthothetes chemungensis					r				a	r				r					c			c								c	
Chonetes cf. vicinus	c																														
C. scitulus																														r	
C. setigerus																			r												
Productella lachrymosa										a				r					a			r				a				r	a
P. cf. lachrymosa									c																						
Schizophoria striatula									c	a									c							c				c	a
Dalmanella tioga																			r												
Camarotœchia stephani																			r			r	r			c				r	c
Leiorhynchus mesacostale																															r
Atrypa reticularis	r																														r
A. spinosa	c				c	c				r																					
Cyrtina hamiltonensis										r																					
Spirifer disjunctus					r	a			a	a				a					a			a	c								c

Delthyris mesacostalis																		a				r				c				c	c
Ambocœlia gregaria																						c				c				c	c
Athyris angelica																										r				c	c
A. cf. angelica																						r									
MOLLUSCA.																															
Glossites lingualis								r										r													
G. procerus																															r
Palæoneilo filosa								r																							
Macrodon cf. chemungensis	r																														
Leptodesma lichas	a								c																						
L. sp.									r									r													
Mytilarca chemungensis																						r									c
Actinopteria sp.																															r
Schizodus chemungensis	r																														
S. oblatus	r																														
Aviculopecten duplicatus																						r									
A. cf. cancellatus																										r					
A. striatus																						r									
Modiomorpha cf. quadrula	r																														
Orthoceras sp.																						r									
Manticoceras cf. complanatus	r																														
Bellerophon sp									r																						
Platyceras sp								r																							
PISCES.																															
Fish bones (fragments)						c																									

ORE-BED SECTION, MANSFIELD.

By E. M. KINDLE.

Chemung rocks are exposed at frequent intervals along the public highway which passes the old iron-ore pit, 3 miles west of Mansfield. The following section is constructed from exposures along this road between the old ore pit and Tioga River.

Section 1459 B at the ore-bed road, Mansfield.

		Ft.	in.
22.	Surface clay	5	0
21.	Brown, soft shaly sandstone	0	8
20.	Gray sandy shale	10	0
19.	Red oolitic iron ore	0	18–24
18.	Reddish calcareous sandstone (in old ore pit)	0	6
17.	Concealed	50	0
16.	Brownish-gray sandstone	5	0
15.	Gray shale and covered	60	0
14.	Shaly sandstone and shale fossiliferous at top	25	0
13.	Concealed	10	0
12.	Dard-gray clay shale and shaly sandstone	5	0
11.	Dark shaly sandstone	1	0
10.	Covered	119	0
9.	Thin-bedded and shaly sandstone	25	0
8.	Covered	6	0
7.	Bluish-gray clay shale	8	0
6.	Covered	20	0
5.	Thin-bedded sandstone	6	0
4.	Covered	140	0
3.	Drab sandy shale and flaggy sandstone	22	0
2.	Covered	42	0
1.	Bluish-gray shale (in bed of creek)	6	0

FAUNULES OF THE ORE-BED ROAD SECTION, MANSFIELD.

Zone 3 of Mansfield section (1459 B).—This zone holds the lowest faunules noted in the section, comprising the following species:

Faunule of zone 3 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Strophonella cælata (c).
2. Orthothetes chemungensis (a).
3. Schizophoria striatula (a).
4. Atrypa spinosa (a).
5. Cyrtina hamiltonensis (r).
6. Spirifer disjunctus (a).
7. Byssopteria radiata (c).
8. Pterinea sp. (r).

Zone 5 of Mansfield section (1459 B).—The beds of zone 4, having a thickness of 140 feet, are not exposed. The species occurring in zone 5 are as follows:

Faunule of zone 5 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (a).
2. Productella lachrymosa (a).
3. Schizophoria striatula (c).
4. Camarotœchia contracta (a).
5. Spirifer disjunctus (a).
6. Delthyris mesicostalis (a).
7. Athyris angelica (a).
8. Leptodesma sp. (r).
9. Crenipecten cf. amplus (r).

Zone 9 of Mansfield section (1459 B).—The following species are found in zone 9, 34 feet above zone 5:

Faunule of zone 9 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Productella lachrymosa (a).
2. Schizophoria striatula (r).
3. Camarotœchia contracta (a)
4. Delthyris mesicostalis (a).
5. Athyris angelica (c).
6. Aviculopecten rugæstriatus (r).

Zone 11 of Mansfield section (1459 B).—The greater part of the section between zones 9 and 11 is concealed. The following faunule is from a 1-foot bed 120 feet above the preceding faunule:

Faunule of zone 11 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Orbiculoidea sp. (r).
2. Orthothetes chemungensis (c).
3. Productella lachrymosa (a).
4. Schizophoria striatula (a).
5. Camarotœchia contracta (c).
6. Cryptonella sp. (r).
7. Delthyris mesicostalis (a).
8. Ambocœlia gregaria (r).
9. Athyris angelica (a).
10. Sphenotus cf. rigidus (r).
11. Glossites cf. depressus (r).
12. Macrodon chemungensis (r).
13. Euomphalus sp. (r).
14. Loxonema sp. (r).

Zone 12 of Mansfield section (1459 B).—The 5 feet of shale and sandstone following zone 11 contain the following species:

Faunule of zone 12 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (c).
2. Chonetes setigerus (r).
3. Productella arctirostrata (r).
4. P. boydi (c).
5. P. lachrymosa (c).
6. Schizophoria striatula (a).
7. Camarotœchia contracta (a).
8. Spirifer disjunctus (r).
9. Delthyris mesicostalis (a).
10. Ambocœlia gregaria (r).
11. Athyris angelica (c).
12. Grammysia sp. (r).
13. Sphenotus contractus (r).
14. Leptodesma lichas (r).

The specimens referred to No. 7, have less angular plications and shallower sinus than specimens of *Camarotœchia contracta* from northwestern Pennsylvania. The shells show—

Plications in sinus, 3–4; generally 3.
Plications on fold, 4; rarely 5.
Plications on each valve, about 16.

Variation in No. 6 occurs chiefly in relation to shape of muscular impression in pedicle valve and in the ratio of length and width. The two latter characters are equal in some individuals. In many the width exceeds the length by one-fourth or more.

No. 9 shows considerable variability in this zone with reference to the number of plications. These vary from 13 to 29 on each valve. The length of the mesial septum is contained in the length of the shell from two to three and a half times. Of 23 specimens examined 22 have one plication and one has a double plication in the sinus. All of the specimens show a double fold except one, which has a third plication weakly developed on the fold.

Zone 15 of Mansfield section (1459 B).—About 20 feet above the preceding faunule were found the following species:

Faunule of zone 15 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Productella lachrymosa (c).
2. Schizophoria striatula (r).
3. Camarotœchia stephani (a).
4. Delthyris mesicostalis (a).
5. Ambocœlia gregaria (r).
6. Athyris angelica (r).
7. Sphenotus contractus (c).
8. Edmondia philipi (c).
9. Aviculopecten sp. (r).

Zone 18 of Mansfield section (1459 B).—One hundred and fifteen feet above zone 14 a thin calcareous bed appears, underlying the iron-ore bed. Only three species were collected from it.

Faunule of zone 18 of Mansfield section (1459 B).

[a, abundant; c, common.]

1. Productella lachrymosa (c).
2. Camarotœchia stephani (c).
3. Spirifer disjunctus (a).

Zone 19 of Mansfield section (1459 B).—Eighteen to 24 inches of red hematite comprise this zone. The only fossils found in it are *Productella lachrymosa* and *Spirifer disjunctus*, which are common.

Zone 21 of Mansfield section (1459 B).—Ten feet above the iron ore the highest faunule of the section appears. It contains the following species:

Faunule of zone 21 of Mansfield section (1459 B).

[a, abundant; c, common; r, rare.]

1. Orthothetes chemungensis (r).
2. Productella lachrymosa (c).
3. Camarotœchia sappho (a).
4. Spirifer disjunctus (c).

The section as a whole shows a fauna of distinctly Chemung type, *Cyrtina hamiltonensis* is the only Hamilton survivor appearing in it. The faunules of the different parts of the section do not offer any sharp contrasts in composition. The accompanying chart, showing the distribution of species in the section, indicates that dominant species, or those appearing abundantly or commonly in any zone, are usually found to range through a number of zones or the entire section.

Faunal chart of the ore-bed road section, Mansfield, Tioga County, Pa. (1459 B).

[a, abundant; c, common; r, rare.]

	Gray sandy shale and sandstone (Chemung).																											Iron ore.		
	1	2	3				4				5, 6	7, 8	9				10				11–13	14		15		16	17		18–22	
					100 ft.						200 ft.					300 ft.					400 ft.					500 ft.				
MOLLUSCOIDEA.																														
Orbiculoidea sp																				r										
Strophonella cælata				c																										
Orthothetes chemungensis				r							a									c									r	
Chonetes setigerus																				r										
Productella arctirostrata																				r										
P. boydi																				c										
P. lachrymosa											a			a						a		c						c	c	
Schizophoria striatula				a							c			r						a		r								
Camarotœchia contracta											a			a						a										
C. stephani																						a								
C. sappho																													a	
Cryptonella sp																				r										
Delthyris mesicostalis											a			a						a		a								
Atrypa spinosa				a																										
Cyrtina hamiltonensis				r																										
Spirifer disjunctus				a							r									r								a	c	
Ambocœlia gregaria																				r		r								
Athyris angelica											a			c						a		r								
MOLLUSCA.																														
Sphenotus contractus																				r		c								
S. cf. rigidus																				r										
Grammysia sp																				r										

Glossites cf. depressus																				r										
Edmondia philipi																						c								
Macrodon chemungensis																				r										
Leptodesma sp											r																			
L. lichas																				r										
Pterinea? sp				r																										
Byssopteria radiata				c																										
Aviculopecten rugæstriatus														r																
A. sp																						r								
Crenipecten cf. amplus											r																			
Euomphalus sp																				r										
Loxonema sp																				r										

CANOE CAMP SECTION.

By E. M. KINDLE.

The section at Canoe Camp begins at the lower cascade in Canoe Camp Creek, near Canoe Camp, Tioga County, Pa., and runs up the ravine and sidehill to the old ore pits on south side of Butts Hill.

Section 1459 A, at Canoe Camp, Pa.

	Ft.	in.
18. Thin-bedded sandstone and shale, olive gray, with some reddish bands near base	12	0
17. Fine-grained oolitic iron ore (thickness concealed)		
16. Concealed	135	0
15. Gray shale	0	20
14. Concealed	4	0
13. Gray shale	2	0
12. Hard gray sandstone	0	8
11. Concealed	2	0
10. Gray soft shale with some bands of hard sandstone	5	6
9. Blue calcareous sandstone full of fossils	0	6
8. Gray shale	6	0
7. Thin-bedded sandstone and shale	6	0
6. Thin-bedded sandstone and bluish-gray shale, with corals	10	0
5. Bluish-gray sandstone full of fossils	0	8–10
4. Drab-colored sandy shale	17	0
3. Concealed (above fall in creek)	140	0
2. Thin-bedded shaly drab sandstone and shale	5	0
1. Grayish-drab sandstone and shale	11	0

FAUNULES OF THE CANOE CAMP SECTION.

The fanules of the Canoe Camp section are all Chemung. They are as follows:

Zone 1 of Canoe Camp section (1459 A).—The lowest zone of the section, which is exposed at the cascade in Canoe Camp Creek, contains the following faunule:

Faunule of zone 1 of Canoe Camp section (1459 A).

[a, abundant; c, common; r, rare.]

1. Strophonella cælata (r).
2. Orthothetes chemungensis (c).
3. Productella lachrymosa (c).
4. Schizophoria striatula (c).
5. Spirifer disjunctus (a).
6. Leptodesma creon.
7. Cypricardella cf. bellistriata (r).

Zone 2 of Canoe Camp section (1459 A).—Five feet of shaly sandstone immediately following the preceding zone contains the following species:

Faunule of zone 2 of Canoe Camp section (1459 A).

[a, abundant; c, common; r, rare.]

1. Stropheodonta (Douvillina) mucronata (c).
2. Strophonella cælata (c).
3. Orthothetes chemungensis (c).
4. Productella cf. lachrymosa (r).
5. Schizophoria striatula (a).
6. Atrypa spinosa (r).
7. Cyrtina hamiltonensis (r).
8. Spirifer disjunctus (a).

The *Sp. disjunctus* of this and the preceding zone belongs to the wide mucronate type of the species. *Schizophoria striatula* and *Strophеodonta (Douvillina) mucronata* are each represented by individuals which are less than half the normal size of the species.

Zone 5 of Canoe Camp section (1459 A).—The outcrops of this and the next zone are in the ravine on the south side of Butts Hill. The faunule comprises the following species:

Faunule of zone 5 of Canoe Camp section (1459 A).

[a, abundant; c, common; r, rare.]

1. Strophеodonta (Douvillina) mucronata (c).
2. Strophonella cælata (r).
3. Chonetes sp. (r).
4. Productella cf. lachrymosa (c).
5. Atrypa aspera (c).
6. Spirifer disjunctus (a).

Zone 6 of Canoe Camp section (1459 A).—This zone afforded the following species:

Faunule of zone 5 of Canoe Camp section (1459 A).

[a, abundant; c, common; r, rare.]

1. Zaphrentis cf. simplex (a).
2. Strophеodonta (Douvillina) mucronata (a).
3. Strophonella cælata (c).
4. Orthothetes chemungensis (a).
5. Atrypa spinosa (c).
6. Cyrtina hamiltonensis (r).
7. Spirifer disjunctus (a).
8. Byssopteria radiata (r).

Zone 18 of Canoe Camp section (1459 A).—The highest zone of the section, exposed just above the old ore pit, furnished the following species:

Faunule of zone 18 of Canoe Camp section (1459 A).

[c, common; r, rare.]

1. Productella lachrymosa (c).
2. Delthyris mesicostalis (c).
3. Athyris angelica (r).
4. Grammysia cf. circularis (r).
5. Leptodesma sp. (r).

Faunal chart of Canoe Camp section, Tioga County, Pa. (1459 A).

[a, abundant; c, common; r, rare.]

	Gray thin-bedded sandstone and shale.																	Oolitic iron ore.				
	1	2	3					4	5–6	7–15							16			17	18	
			100 feet.						200 feet.								300 feet.					
CŒLENTERATA.																						
Zaphrentis cf. simplex									a													
MOLLUSCOIDEA.																						
Stropheodonta (Douvillina) mucronata	c								c													
Strophonella cælata	c								c													
Orthothetes chemungensis	a								a													
Chonetes sp									r													
Productella lachrymosa	c																			c		
P. cf. lachrymosa									c													
Schizophoria striatula	a																					
Delthyris mesicostalis																				c		
Atrypa spinosa	r								c													
Spirifer disjunctus	a								a													
Cyrtina hamiltonensis	r								r													
Athyris angelica																				r		
MOLLUSCA.																						
Cypricardella cf. bellistriata	r																					
Grammysia cf. circularis																				r		
Leptodesma creon	c																					
Leptodesma sp																				r		
Byssopteria radiata									r													

CORRELATION OF THE TIOGA, MANSFIELD, CANOE CAMP, AND ARMENIA MOUNTAIN SECTIONS.

By E. M. KINDLE.

The Tioga section includes the lowest and the highest beds exposed in the quadrangle, so far as known, extending from the Sharon conglomerate several hundred feet down into the Chemung. The upper third of the section is barren of fossils, except for a few fish teeth in the arenaceous limestone bed in the upper part of the section (1460 A52). This bed is of some importance, because its peculiar lithological features make its recognition possible whenever encountered over a considerable area. The best exposures of this bed and the associated shales and sandstones occur near the summit of Armenia Mountain, 2 miles west of Troy, in Bradford County. The section, from the highest beds exposed near the summit, is as follows:

Section 1458 B, at Armenia Mountain.

	Feet.
31. Greenish-gray coarse micaceous thin-bedded and cross-bedded sandstone	10
30. Concealed	20
29. Mottled light greenish-gray arenaceous limestone, with frequent lumps of shale and occasional fish remains	5
28. Thin-bedded greenish-gray sandstone, showing false bedding	20
27. Green sandy shale	5
26. Soft red shale	18
25. Heavy-bedded greenish-gray sandstone, tending to split easily and running into shale in a short distance	30
24. Greenish shale and thin-bedded sandstone	15
23. Greenish brecciated shale bed	1
22. Soft green shale	9
21. Green, coarse, heavy-bedded micaceous sandstone, with some plant remains and a few shale bands	35
20. Soft red clay, scarcely showing stratification	25
19. Bright-green sandstone	1
18. Soft red shale	5
17. Green and red shale	13
16. Soft red shale	10
15. Green heavy-bedded sandstone	4
14. Red soft argillaceous indistinctly stratified shale	11
13. Green massive sandstone	8
12. Red and green shale and sandstone, color varying rapidly at the same horizon	20
11. Red shale, green sandstone, and covered	140
10. Red shale, with an occasional band of sandstone, lower 20 feet covered	50
9. Red sandstone	5
8. Concealed	90
7. Cross-bedded red sandstone	10
6. Concealed	180
5. Red shale and sandstone	30
4. Red sandstone, full of worm (?) trails	25
3. Hard red sandstone, with numerous fish remains	3
2. Concealed	10
1. Red sandstone	6

The limestone (No. 29 of the section) contains probably not more than 25 per cent of lime, but since no other bed in the section above the Chemung contains an appreciable quantity of lime, it is regarded as a limestone. It will be designated the Armenia limestone lentil; it occurs in the upper part of the Oswayo formation.

The Armenia Mountain section lies about 14 miles southeast of the Tioga section and 10 miles northwest of the South Mountain section. The detailed Armenia section as given above may be safely assumed to represent closely the concealed upper part of the Tioga section. The Armenia limestone is easily recognizable in each of the three sections. The few fish remains occurring in this bed are of Carboniferous type. Below the Armenia limestone occasional plant remains are the only fossils seen until beds containing Catskill fishes are reached. The beds in which these fossils appear abundantly lie in the South Mountain section 797 feet below the horizon of the Armenia limestone and in the Armenia Mountain section 754 feet below the same horizon.

As yet no invertebrate paleontological data are available for drawing any sharp line of distinction between the Devonian and Carboniferous sediments. In the absence of entirely adequate data for determining this boundary it is perhaps most convenient and practicable to consider the latest appearance of Catskill fish remains as marking the end of the Devonian period. This horizon occurs in the section near the division line between the Cattaraugus and Oswayo of the Elkland-Tioga folio.

In the few sections in this region showing nearly continuous exposures from the Chemung fauna to the Sharon conglomerate there is seen to be very slight basis for a division on the basis of color, the red beds being nearly as common in the upper as the lower portions. It will be noted, however, in examining average sections where the greater part is covered that red beds *appear* to be most abundant in the lower third of the section. This is largely due to the fact that the lower beds are very generally tough sandstones which are apt to outcrop prominently, while the upper red beds are nearly all soft shales which are likely to outcrop less conspicuously, if at all. This tendency of the upper red beds to be soft shales and the lower to be tough, flaggy, and often cross-bedded sandstones is correlated with their faunal characteristics—the upper red and gray beds being, with the exception of the Armenia limestone, entirely barren of animal remains, while the lower contain numerous fish remains.

The invertebrate fauna, from the lowest beds of the section to its termination upon the appearance of sediments of Catskill type, is distinctly Chemung in character.

Most of the sections in the region about Mansfield are characterized by one or more beds of iron ore. There appear to be three of these

beds, but no single section shows more than two of them. Beds of similar character, but with a lower grade of ore, occur at the same horizon near Leroy.

The limestone facies represented in most of the sections of western Bradford County below the ferruginous sandstone and ore beds by the limestone of the Franklindale beds has almost entirely disappeared in the Tioga sections. It appears to be represented, however, at a few localities by a thin bed of limestone composed of shell fragments. A bed of this character not now exposed, which is said to be 5 or 6 feet in thickness, occurs in the hill 1 mile north of Mansfield. In the southeast corner of the county this limestone outcrops 2 or 3 miles east of Roaring Branch, along the Lycoming Creek wagon road.

While the Franklindale beds have thinned almost to the vanishing point west of the Tioga-Bradford county line, the iron-ore beds, which at Leroy accompany and lie above the Franklindale beds, have become more pronounced and carry a higher grade of ore. The peculiarities of the different ore beds are not sufficiently marked, either paleontologically or lithologically, to enable one to correlate with confidence the individual ore beds of the Mansfield region with those of the Leroy region; but that the Mansfield ore beds and intervening strata, as a whole, should be correlated with the ferruginous sandstones and ore beds at Leroy is indicated by the following considerations:

(1) The highest ore bed lies approximately at the same distance below the upper limit of fossils at Leroy and Mansfield.

(2) The iron ores and their associated strata represent the first appearance of red sedimentation in both districts.

(3) A limestone which is apparently the equivalent of that at Leroy is present at some localities in the ore-bed sections of the Mansfield region.

COMMENTS ON THE FAUNAS OF THE TIOGA, MANSFIELD, AND CANOE CAMP SECTIONS.

By H. S. Williams.

There are some interesting facts regarding the faunas associated with the red beds and iron-ore deposits in the eastern part of the Tioga quadrangle.

In each of the three sections examined in detail (Mansfield, Canoe Camp, and Tioga) there are two faunas which occur in succession, lapping a little, but in the main distinct in composition. This is shown by the following analysis of the faunas:

The first point noticed is that *Strophonella cælata* is conspicuous in the earlier zones of each section, while *Athyris angelica* is dominant in the higher faunules, and these two species do not occur together in

any of the faunules reported. Prominent among the associates of *Strophonella cælata* are *Stropheodonta* (*Douvillina*) *mucronata*, and in the lowest faunule of Tioga section, also *Stroph.* (*Leptostrophia*) *perplana* var. *nervosa*, and *Stropheodonta* (*Douvillina*) *inæquistriata*, *Spirifer disjunctus*, and *Atrypa spinosa*, none of which species are associated with *Athyris angelica*.

In the higher zone common associates with *Athyris* are *Delthyris mesicostalis*, and *Camarotœchia contracta*, neither of which is seen associated with *Strophonella*. *Schizophoria striatula*, *Productella lachrymosa*, and *Orthothetes chemungensis* are common to both faunas.

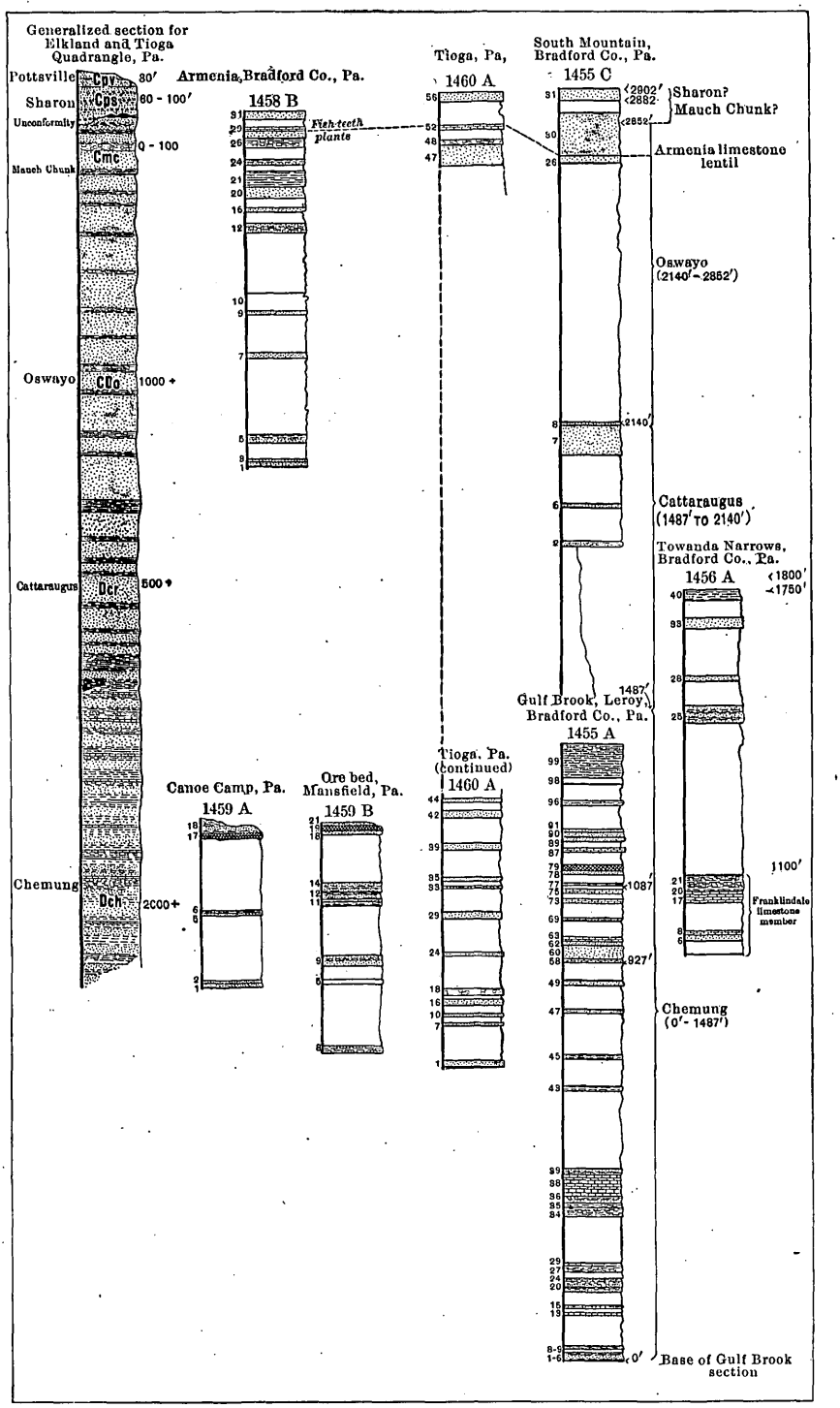
Athyris angelica is rare in the eastern extension of the Chemung fauna, but whether its absence is associated with the fact that the higher Chemung faunas are cut off in the east by the red beds, or because of limited geographical range during the same portion of time, is not evident from the facts at hand. As was pointed out in Bull. U. S. Geol. Survey No. 41, *Athyris angelica* is a prevailing species in the upper Chemung horizons of the Genesee Valley sections. In the survey of that region, *Strophonella cælata* was not discovered. But it is also to be noted that *Spirifer disjunctus* is a very common species in the typical Chemung fauna of western New York, and is there frequently associated with *Athyris*. It is not a very frequently occurring species in the typical Chemung beds of the more eastern sections, although it is very abundant in some zones.

The faunal indications of these Tioga County sections therefore favor the view that both the *Strophonella* and *Athyris* zones are well up in the Chemung formation; and, according to the opinion of the writer, are to be correlated stratigraphically with beds occupying the higher hilltops of the Waverly quadrangle, above the fossiliferous zones of the cliffs along Chemung River at Chemung Narrows and Waverly. Fuller collections of fossils from this and neighboring regions will throw light upon this problem.

COMMENTS ON THE CORRELATION OF THE SECTIONS OF BRADFORD AND TIOGA COUNTIES, PA.

By H. S. WILLIAMS.

In Pl. IV the several sections of Bradford and Tioga counties, measured by E. M. Kindle, the faunules of which are discussed in the previous pages, are arranged according to the evidence furnished by the contained fossils. Placed to the left of them is the section (generalized) of the Tioga folio as prepared by M. L. Fuller. The sections are all drawn to same scale, and the lower ones are correlated according to contained fossils, while those at the top of the series are correlated by the beds supposed to represent the Mauch Chunk and Sharon formations.



SECTIONS IN BRADFORD AND TIOGA COUNTIES, PA.

The three sections on the right represent a single measured set of beds near one another. The gap which is covered in the valley of Towanda Creek is estimated from the dip of the beds on each side, so that it is believed the total length of the section is approximately correct. In this section 1,487 feet are referred to the Chemung formation, the Chemung species prevailing to the top. The top of the Franklindale calcareous beds is 400 feet down in the Chemung, and its thickness is 160 feet in the Gulf Brook section (zones 75 to 58). From the top of the Chemung to an arbitrary line drawn between the Cattaraugus and Oswayo (at 1455 C8) is 653 feet; this is the estimated thickness of the Cattaraugus for this section.

The correlation of the Towanda Narrows section (1456 A) with the Gulf Brook (Leroy) section (1455 A) is made by means of the upper calcareous zone of the Franklindale limestone beds—1456 A17 and 20, being correlated with 1455 A73 and 75. As both of these sections are based on detailed measurements of the individual zones, this places zone 1456 A40, which contains an unmistakable Chemung faunule, a little over 1,700 feet above zone 1455 A8, which also holds a distinctly Chemung faunule, and over 250 (top 263) feet above the arbitrary line drawn at top of the Chemung formation. This arbitrary line is drawn as being approximately the place of beginning of typical Catskill red sedimentation; below, for several hundred feet, appear occasionally dull reddish and purplish beds, but no considerable bright red sandstones. It is not imagined that this upper zone of Chemung species, 1456 A40, is in reality the highest place of occurrence of this fauna. Further search will be likely to show species of this fauna as long as the marine conditions were persistent in the neighborhood of this section. The stopping of the marine Chemung invertebrates is supposed to have been occasioned by a change of local conditions which was associated with deposition of the red beds, and locally drove out the species from the region, but did not destroy them. This interpretation seems best to explain the irregularity of the line of separation between Chemung and Cattaraugus.

The interval between the top of zone 1456 A40 of the Towanda Narrows section and the observed base of the South Mountain section on the opposite side of the Towanda Creek Valley is estimated to be about 100 feet. The rocks are all covered and the estimate is based on dip and actual barometric determination of altitude of the several outcrops. This estimate may be too great or too little, but the measuresments of the sections otherwise are based upon actual distances from zone to zone as measured at the outcrops.

The red beds prevail in the observed outcrops from the base of the South Mountain section to zone 1455 C26, which is correlated with the Armenia limestone lentil of the section on Armenia Mountain (1458 B29). Nevertheless, as Kindle states on a previous page, the red

outcrops are less conspicuous in the upper part of the section than below the fish bed (1455 C8) at the the top of which is abitrarily drawn the division line between the Cattaraugus and Oswayo, thus giving to the Cattaraugus a thickness of 653 feet, as before stated.

The Armenia section (1458) is made up of prevailingly red beds up to the base of 1458 B21. This is a green, coarse, heavy-bedded micaceous sandstone with some plant remains, and divided by a few shale bands and is 35 feet thick. Above this to the top of the section the beds are green and gray, except zone B26, which is a soft red shale 18 feet thick, situated 25 feet below the Armenia limestone lentil (1458 B29). This gives about 100 feet of gray beds below the Armenia limestone lentil in western Bradford County. The upper part of the Tioga section, 4 miles east of Tioga (1460 A), shows a coarse white sandstone with angular quartz pebbles, of 20 feet thickness, at the top. This is called the Sharon conglomerate member of the Pottsville conglomerate by Fuller, in the Elkland-Tioga folio. There seems no reason to doubt the general equivalency of the conglomerate (1455 C31) with this upper zone of the Tioga section (1460A). But the correlation of the horizon of this and the immediately underlying beds is in this paper made on basis of determination and nomenclature already published in the Elkland-Tioga folio, without attempting to discuss the validity of that determination. On similar ground the uppermost cross-bedded sandstone of the Armenia section (1458 B31) is called Sharon conglomerate in this paper. The Armenia limestone lentil of the Tioga section (1460 A52) is a zone 10 feet in thickness 46 feet below the sandstone and contains fish teeth and lumps of shale. A red shale zone 10 feet thick is separated from the base of the latter by 30 feet of gray beds.

On the basis of red beds and fish remains the equivalent of the Catskill of early literature might be carried down at least to the base of the Franklindale limestone member, 927 feet above the base of the Gulf Brook section; but on the basis of marine invertebrate fossils the Chemung formation runs up to at least zone 1456 A40, or to 1,750 feet above that base, a difference of 823 feet thickness of strata for the overlapping of these two conditions.

This interval may be called Chemung, Cattaraugus, or transition beds of Chemung, Catskill, or Chemung-Catskill, according to the prejudice of the authors. Whatever name is applied to the various parts of the section it is clear to the paleontologist that as one passes from eastern Pennsylvania and New York westward across the sections, the place of first appearance of the red beds is at a later stage of evolution of the faunas. In any particular locality the length of the interval from the first appearance of the red beds to the final deposition of the marine Chemung faunas was probably determined by the degree of persistence with which the changed conditions marked

by the red deposits prevailed at that spot. The evidence at hand points to a greater persistence of the red sedimentation in the eastern than in the western sections. But only as the time horizons are determined by the fossils is it possible to correlate equivalency of horizons across the regions which thus differ in the character of the sediments laid down. The application of formational names therefore on the basis of likeness in the character of the sediments, which are known to geographically differ, must necessarily be regarded as not significant of actually synchronous time divisions.

GENERAL INDEX.

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