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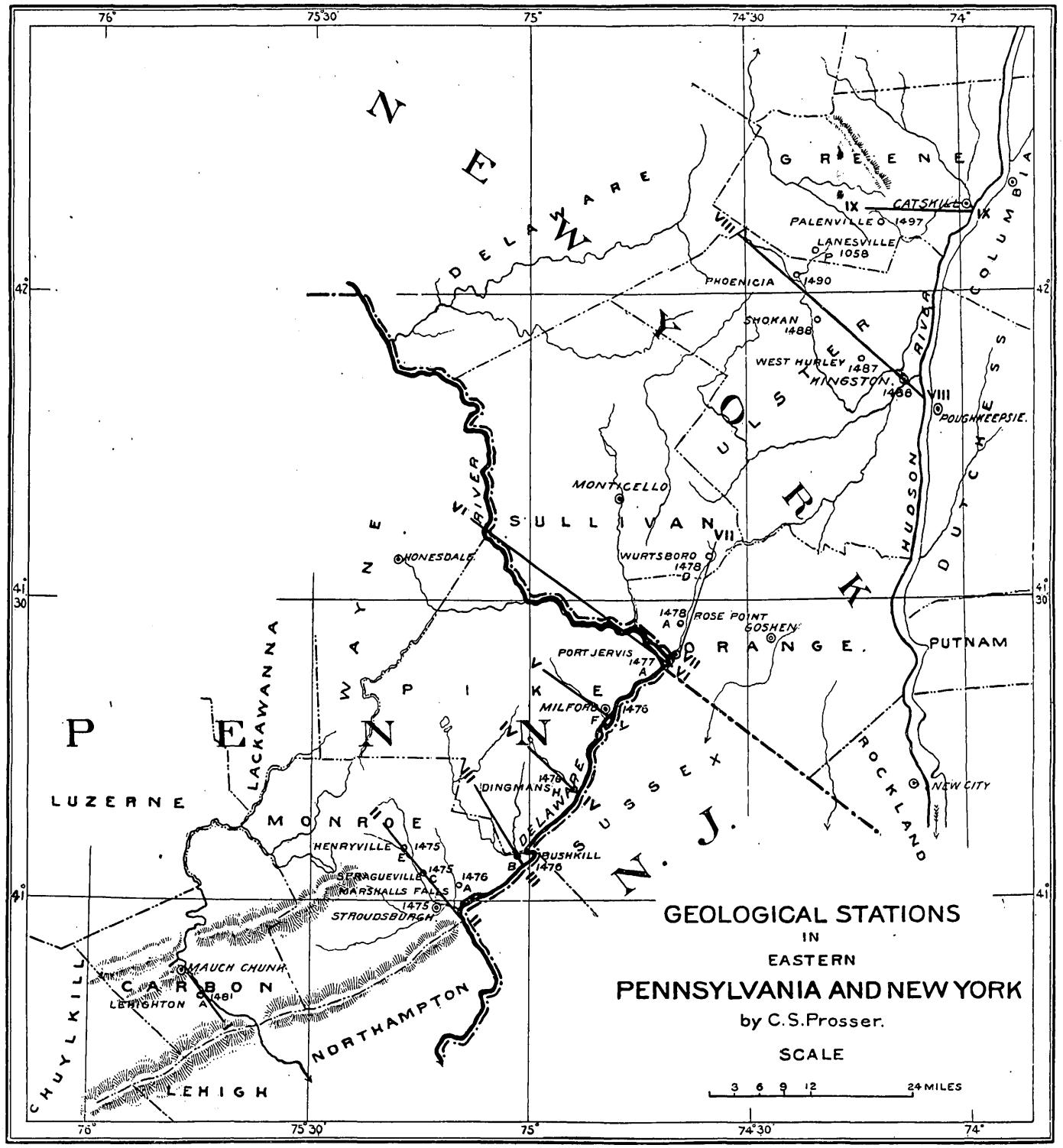
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122. Results of Primary Triangulation, by Henry Gannett.

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TO THE DIRECTOR OF THE
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

WASHINGTON, D. C., *September, 1894.*

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J. W. POWELL, DIRECTOR

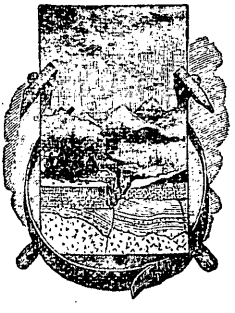
THE DEVONIAN SYSTEM

OF

EASTERN PENNSYLVANIA AND NEW YORK

BY

CHARLES S. PROSSER



WASHINGTON
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1894

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DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
Washington, D. C., June 1, 1894.

SIR: I have the honor to transmit herewith for a bulletin of the Geological Survey a paper entitled "The Devonian System of Eastern Pennsylvania and New York," by Mr. Charles S. Prosser.

CHAS. D. WALCOTT,
Geologist in Charge.

HON. J. W. POWELL,
Director U. S. Geological Survey.

OUTLINE OF THIS PAPER.

The following paper is an account of a field investigation of the Devonian system of eastern Pennsylvania and New York. The work was undertaken under the auspices of the U. S. Geological Survey for the purpose of comparing the formations of this region with the more typical sections of the Devonian system in central and western New York.

The first field work was done in 1884, when a section was made from Port Jervis, along the line of the Monticello and Port Jervis Railroad, to Monticello, and through Sullivan County over exposures of the Catskill stage. In 1890 the various outcrops were studied along the Ulster and Delaware Railroad from Kingston to the Grand Hotel station, and along the Stony Clove and Catskill Mountain Railroad from Phœnicia to Kaaterskill and Palenville.

During the following year an examination was made of the Devonian exposures along the Lehigh River, in Carbon County, Pennsylvania, along the Delaware, Lackawanna and Western Railroad across Monroe County, then northeast over the Devonian to Port Jervis, when the Delaware River section was studied, and finally from Port Jervis up the Neversink Valley to Summitville, on the New York, Ontario and Western Railroad, in Sullivan County, New York.

The stratigraphy of the region was studied while thorough search was made for fossils in all the exposures examined. The collections of fossils have been carefully identified, and the data obtained in this way have been used in comparing the formations of this region with those of central New York. Such comparative study has shown differences in classification between the system used by the Pennsylvania survey and that of the New York standard series, and certain changes are suggested which will bring the correlation of the Pennsylvania section nearer that of the New York.

A change of location and an accession of duties have rendered it impossible to continue this study in eastern New York and central Pennsylvania, as had been planned by the writer; consequently it is deemed best to publish now the results of this portion of the investigation. As a result of this change the paper fails to show that fullness of detail and extent of scope which was desired by the writer; but it is hoped that the contribution may be of some assistance in working out the correlation of the Devonian system of this region.

TOPEKA, KANS., *July 5, 1893.* C. S. P.

THE DEVONIAN SYSTEM OF EASTERN PENNSYLVANIA AND NEW YORK.

By Charles S. Prosser.

INTRODUCTION.

By way of introduction a section will be described across the Devonian of the northeastern part of Monroe County, Pa., along the line of Brodhead Creek and the Delaware, Lackawanna and Western Railroad. The base of this section will rest on the Corniferous limestone well exposed in a railroad cut a mile south of East Stroudsburg and the termination will be in the Pocono, as exposed on the Pocono Mountains, from Mount Pocono to the ridge northwest of Tobyhanna.

STROUDSBURG, MONROE COUNTY, PA.—1475.[1]

One mile south of East Stroudsburg the Delaware, Lackawanna and Western Railroad makes a cut through an anticlinal axis of the Corniferous limestone, near the center of which is the Cauda-galli grit.[2] On the western side of Brodhead Creek, along the line of the New York, Susquehanna and Western Railroad, are exposures of the Corniferous limestone which in some respects show the folding better than those on the eastern side of the creek. A very small anticlinal fold occurs just south of the railroad bridge across McMichael's Creek, most of the rock being eroded so that only an occasional stratum shows. Then the rocks are for a short distance covered, when the limestone again appears with a dip of 30° from 10° to 15° east of south. Under this limestone, at the north end of the bluff, are very black Marcellus shales which have been excavated in the hope of finding coal. This structure shows it to be an overturned dip of the Corniferous. South of the limestone the rocks are covered for about 100 feet, when an anticlinal arch of limestone is exposed along the railroad for 105 feet. If the small ridge of limestone just south of McMichael's Creek be followed a short distance southwest, an exposure of shaly limestone will be found in which fossils are abundant. (1475 B 4.)[3]

[1] Station number shown on map (Pl. I) accompanying this bulletin.

[2] This cut is well described by Prof. White in 2d Geol. Survey Penn., G[6], pp. 119, 265, 266, where it is stated that the Corniferous limestone has a thickness of about 200 feet, and that 50 feet of the Cauda-galli grit is exposed at the center of the arch.

[3] This is probably the locality mentioned by Prof. White as one of the best in Monroe County for collecting Corniferous fossils (G[6], p. 120). On pp. 120, 121 he gives a list of eleven species from this and other localities in Monroe County. Also see paragraph on p. 266 in reference to the East Stroudsburg axis of Corniferous just south of Stroudsburg.

Down the ridge, toward the iron bridge, across the creek, opposite Elizabeth street, as well as at the point where the highway turns down the creek, is a ledge of the cherty Upper Helderberg (Corniferous) limestone containing corals and a few other fossils.

No. 1475 B 2—Bluish gray shales occur in McMichael's Creek, opposite Elizabeth street, the dip of which is between 25° and 30°, one clear stratum giving 27° to 28°, 20° or more west of north. The cleavage is to the south rather than to the southeast.[1] These shales are the transition from the Corniferous limestone up into the black Marcellus, and at this point 45 feet are exposed. No fossils were found.

No. 1475 B 1.—At the northeast end of the small ridge which rises a little north of Scott street, Stroudsburg, is an outcrop of blackish shales.[2] The ridge extends northeast and southwest, and is probably produced by one of the small folds. The rock has the lithologic character of the Marcellus shale of New York, and the fossils given below show this correlation to be correct. Fossils are comparatively abundant in this locality, and it is one of the few places which has yielded Marcellus fossils in northeastern Pennsylvania. Prof. White stated that this is the only locality at which he found fossils abundant in the Marcellus,"[3] and he provisionally identified the following genera: "*Spirifer*, *Chonetes*, *Productus*, *Orthis*, with many *crinoidal* fragments."[4]

Of course the *Chonetes* is the *C. mucronata* and the *Orthis* is probably *Leiorhynchus limitaris;* but the forms called *Spirifer*[5] and *Productus* are not so easily referred to their proper systematic position.

FAUNA of No. 1475 B 1.

Leiorhynchus limitaris (Van.) Hall	(aa[6])
Chonetes mucronata Hall	(aa)
Leiopteria lævis Hall	(a)
Styliola fissurella Hall	(c)
Orthoceras subulatum Hall (?[7])	(r)
Pterinopecten dignatus Hall	(rr)
(?) Goniatites sp., crushed and imperfect fragment	(rr)

[1] See G[6], p. 269. In describing this locality Prof. White mentions "thin bands (3 to 5 inches thick) of a light drab colored rock," which is interstratified with the bluish gray shale at intervals of 3 to 5 feet. These bands are thin layers of limestone, showing the drab color only on the weathered surface.

[2] This is the outcrop mentioned by Prof. White, on pp. 115, 116, 270 of G[6], and at the last reference we find this statement: "It has been quarried to some extent for riprap for the roads."

[3] G[6], p. 115.

[4] Op. cit., p. 116.

[5] Prof. White stated: "*Spirifer umbonatus* was not recognized anywhere in the district (G[6], p. 116), and Prof. Lesley, in commenting on the above fossils of Stroudsburg, said; "*Spirifera* (*Ambocœlia*) *umbonata*, the little shell so extremely abundant in western New York, was not seen by Prof. White anywhere between the Delaware and Schuylkill rivers." (Sum. Desc. Geol. Penn., Vol. ii, p. 1206, f.n. ‡). By referring to the lists of Hamilton fossils in this paper, it will be seen that *Ambocœlia umbonata* (Con.) Hall, is a common species in northeastern Pennsylvania. It is second in abundance in the exposure a short distance above Gravel Place, 2½ miles above Stroudsburg.

[6] The following characters are used to indicate the abundance of the species: aa = very abundant, a = abundant; cc = very common, c = common; rr = very rare, r = rare.

[7] (?) following the name of a species indicates that the specific identification is in doubt; (?) preceding the generic name indicates that the generic identification is doubtful.

Along the line of the Delaware, Lackawanna and Western Railroad, north of East Stroudsburg, there has been considerable folding of the rocks, and the Upper Helderberg (Corniferous limestone) appears again as shown on Prof. White's geological map of Monroe County. Especially is this discernible in a small cut a little above the flag crossing on the western side of the track, about three-fourths of a mile north of the station and in a field on the eastern side of the railroad a little farther north.

GRAVEL PLACE, MONROE COUNTY, PA.—1475 C 2.

At a point 2.7 miles north of the Stroudsburg station of the New York, Susquehanna and Western Railroad is its junction with the Delaware, Lackawanna and Western Railroad. A short distance farther north, just beyond the point where the Delaware, Lackawanna and Western crosses the highway, is an exposure of rather coarse arenaceous shales on the northeast side of the railroad. Here fossils are quite abundant, especially *Vitulina pustulosa* Hall. The dip of the shales near the top of the bluff is between 22° and 23°, about 20° west of north. The rocks cleave strongly between 20° and 30° east of south, and the position of the fossils shows that it is cleavage passing across the line of bedding.

FAUNA OF NO. 1475 C 2.

Vitulina pustulosa Hall ..... (aa)
Over fifty specimens were collected, some of which are very perfect, showing the pustulose character very nicely.
Amboccelia umbonata (Con.) Hall ..... (c)
Phacops rana (Green) Hall ..... (r)
Spirifera mucronata (Con.) Billings ..... (r)
(?) Nyassa arguta Hall ..... (rr)
Broken and imperfect specimen.
Spirifera granulifera Hall ..... (rr)
Chonetes deflecta Hall ..... (r)
Modiomorpha subalata (Con.) Hall ..... (rr)
Pterinea flabellata (Con.) Hall ..... (rr)
Leiorhynchus multicosta Hall ..... (rr)
Modiomorpha concentrica (Con.) Hall ? ..... (rr)
Specimen broken and crushed so it is not possible to be absolutely sure of specific identity.
Pleurotomaria sp ..... (rr)
Crinoid (calyx) .....

The lithologic character of the rocks is that of the moderately coarse arenaceous Hamilton shales of central New York, and the fauna is undoubtedly Hamilton.

No. 1475 C 3.—The hills on the northeast side of the railroad are quite steep, and above Gravel Place, at a point opposite that at which the railroad crosses the highway for the third time, is an exposure of arenaceous shales, the lithologic character of which is about the same as that of C 2, and fossils are common; *Palæoneilo constricta* (Con.) Hall occurs, and *Spirifera mucronata* is comparatively abundant.

BRODHEAD CREEK SECTION.

No. 1475, C1.—In Brodhead Creek, at Smith and Miller's mill (formerly Stokes' and also Wyckoff's), a little below Gravel Place, is an exposure of Marcellus shale of a bluish gray tint with drab markings, apparently belonging to the lower Marcellus. The dip is west of north, and in two places between 10° and 20°. No fossils were found.[1]

On the highway west of the creek, near the top of the small ridge, south of the 3-mile board, are bluish black shales by the roadside, probably Marcellus, while on the ridge north of the sign-board and house the Hamilton appears.

No. 1475 C 5.—Continuing north along the Stroudsburg and Spragueville highway, at a point a short distance south of the house of E. Bonynge, is an exposure of arenaceous slightly calcareous shale by the roadside. Fossils are very abundant at this horizon, especially Corals and Crinoid stems, and numerous specimens of Brachiopods. The rock when weathered becomes rotten and filled with perforations left by the solution of the Corals and Crinoid stems.

FAUNA OF No. 1475 C 5.

Tropidoleptus carinatus (Con.) Hall ..... (rr)
Atrypa reticularis (Linné) Palm ..... (c)
Spirifera fimbriata (Con.) Hall ..... (a)
Spirifera sculptilis Hall ..... (a)
Spirifera mucronata (Con.) Bill ..... (c)
Spirifera medialis Hall (?) or Spirifera macronota Hall (?) ..... (rr)
Specimen with very high hinge area, but poorly preserved in other respects.
Cyrtina hamiltonensis Hall ..... (r)
Orthis vanuxemi Hall ..... (c)
Nucleospira concinna Hall ..... (c)
Athyris spiriferoides (Eaton) Hall ..... (c)
Chonetes coronata (Con.) Hall ..... (rr)
Strophodonta perplana (Con.) Hall (?); it is possible these internal impressions are S. demissa (Con.) Hall ..... (rr)
Leiorhynchus multicosta Hall (?) ..... (rr)
Poorly preserved specimen.
Cypricardinia indenta (Con.) Hall ..... (c)
Conocardium sp ..... (rr)
Phacops rana (Green) Hall ..... (c)
Platyceras sp., two exfoliated specimens which may be compared with P. carinatum Hall .....
Actinopteria decussata Hall (?) ..... (r)
The rays are regularly interrupted by the concentric striæ, as in the above species.
Mytilarca (Plethomytilus) oviformis (Con.) Hall ..... (rr)
Corals .....
Bryozoa .....

No. 1475 C.

Phacops rana (Green) Hall ..... (rr)
A very perfect specimen from the roadside between No. 1475 C 5 and the bridge over Brodhead Creek.

[1] See p. 270, G 6.

After describing the locality from which the above species were collected, Prof. White said: "There can be little doubt that this stratum represents the Tully limestone horizon of the New York Reports, and it thus becomes a valuable guide in correlating and classifying the rocks of the district."[1]

Again, the same exposure is described more fully under the geology of Stroud Township, where the professor states that the rock is "perforated in every direction with the holes left from the removal of corals and other calcareous remains by solution.

"Fossil shells are very abundant, *Spirifer*, *Tropidoleptus*, and *Avicula* being very numerous, while crinoidal fragments also abound."[2]

The Pennsylvania horizon under consideration is usually a calcareous shale, instead of a massive limestone, and does not lithologically resemble the Tully limestone of central New York. But far more important than its lithologic character is the fact that in this horizon the species which are especially characteristic of the Tully limestone are absent, while those of the Hamilton constitute its fauna.

While considering the correlation of this zone it is well to take into account the known eastern extension of the Tully limestone of central New York. The farthest east Vanuxem found this formation was in Chenango County, "at the northwestern part of Smyrna, on the road to De Ruyter village, where the road crosses the west branch of the Chenango."[3]

Prof. Emmons in 1846 discussed the absence of the Tully limestone in eastern New York, and I see no reason for dissent from his views. He said: "The Hamilton shales, however, are limited above, or superiorly, by a dark-colored mass which has been called the Tully limestone. This would seem a sufficiently distinct limit if the limestone extended eastward; but as it is absent in the river counties, and scarcely extends beyond the central counties in this direction, the group is still left without a distinct line of demarcation in nearly one-half of the State. We are therefore obliged to resort to a careful study of its fossils in order to define the limits which the mass occupies."[4] Also "in Albany and Schoharie counties it [Tully limestone] is unknown."[5]

In the summer of 1886 the writer studied this region, and near Upperville, in Smyrna Township, reported limestone layers 25 feet in thickness separated by calcareous shales.[6] Prof. S. G. Williams reports this same locality as "the easternmost point at which I have found anything answering to the Tully."[7] Finally, Prof. H. S. Williams says: "The Tully limestone is a zone of argillaceous limestone ranging

[1] G6, p. 109.
[2] Op. cit., p. 271.
[3] Geol. New York, Pt. III, 1842, p. 292; also, see p. 164.
[4] Agriculture of New York, Vol. I, p. 183.
[5] Ibid., p. 186.
[6] Proc. Am. Asso. Adv. Science, Vol. XXXVI, 1887, p. 210.
[7] Sixth Ann. Rept. State Geol. [New York], 1887, p. 18; also see map on "Geographical distribution of the Tully limestone in central New York," accompanying the paper.

from a few feet to over 50 feet in thickness, the outcrop of which crosses the middle counties of New York State from Ontario to Chenango counties, but it is not clearly recognized in the sections south of New York."[1]

No. 1475 C4.—About one-fourth mile farther north than the outcrop of the coral zone the road crosses Brodhead Creek, and under the bridge, as well as along the west bank of the creek below the bridge, are exposures of rather fine argillaceous shales of bluish color and moderately fossiliferous.

FAUNA OF NO. 1475 C4.

Nuculites triqueter Con	(rr)
Phacops rana (Green) Hall	(rr)
Palæoneilo sp., a broken specimen; probably P. constricta (Con.) Hall	(rr)
Leiorhynchus multicosta Hall	(rr)
(?) Crania, imperfect specimen of possibly C. hamiltoniæ Hall	(rr)
(?) Streptorhynchus sp., broken specimens of what are apparently S. chemungensis (Con.) Hall, agreeing most nearly with var. arctostriata Hall	(rr)
Orthonota (?) parvula Hall	(rr)
The proportions and other characters of the shell agree perfectly with the description and figures of this species.	
(?) Modiomorpha mytiloides (Con.) Hall	(rr)
Two valves of small Lamellibranch, which are possibly this species.	
(?) Productella sp., two small impressions	(rr)
Chonetes deflecta Hall (?)	(rr)
Not clearly preserved, but the spines along the hinge line are distinct.	
Loxonema sp., only one perfect volution; but probably L. hamiltoniæ Hall	(rr)
Lingula sp	(rr)
Grammysia sp	(rr)
Orthoceras sp	(rr)
Fragments of two shells belonging to the Pectinidæ	(rr)
Crinoid stems	(c)

This outcrop is one of the typical exposures of Genesee shale mentioned by Prof. White, who says: "The Genesee slate outcrop crosses Brodhead Creek at the road crossing, 1¼ miles below Sprague ville, where it is seen as a bluish-black, sandy slate, dipping quite rapidly to the northeast."[2]

From the above list of fossils it will be seen that the fauna is not that of the Genesee shale, but of the Upper Hamilton. Moreover the shales have no lithologic resemblance to the typical Genesee of central and western New York, and the same criticism applies to this correlation that has already been made in reference to the coral zone, or so-called Tully limestone. In reference to the eastern extension of the Genesee shale in New York, Vanuxem said: "The Genesee slate was not distinctly recognized east of the town of Smyrna, in Chenango County, probably owing to intermixture with sandstone, and its fossils not having been noticed."[3] But under the description of Chenango County it is mentioned at North New Berlin.[4] In 1883 the writer

[1] Bull. Geol. Soc. Am., Vol. I, 1890, pp. 489, 490.
[2] G[6], p. 271; also see p. 108 under the distribution of the Genesee.
[3] Geol. of New York, Pt. III, p. 169.
[4] Ibid., p. 292.

carefully studied the exposures along the valley of the Unadilla River to New Berlin and then across the hills to Oneonta, but failed to find any evidence of the Genesee black shale or its fauna. Near Smyrna were found black argillaceous shales some 20 feet in thickness.[1]

No. 1475 C6.—Bluish, arenaceous shales by the roadside, just above the Delaware, Lackawanna and Western Railroad crossing, about one-half mile south of Spragueville. The rock is rather micaceous, and is composed of quite coarse arenaceous shales with some sandstone and thin shaly layers in which are fossils, so that, lithologically considered, it is quite different from the darker and more argillaceous shales of the so-called Genesee below.

FAUNA OF NO. 1475 C6.[2]

Tropidoleptus carinatus (Con.) Hall	(rr)
Homalonotus dekayi (Green) Emm	(rr)
Paracyclas lirata (Con.) Hall	(rr)
Palæoneilo maxima (Con.) Hall	(rr)
Leptodesma rogersi Hall (?)	(rr)
There are three specimens which agree well with some of the figures of the above species, and a fourth specimen is narrower, more oblique, and resembles somewhat fig. 13, Pl. XXI of L. spinigerum (Con.) Hall. Prof. Hall says, "specific distinction is not always apparent" (Geol. Surv. N. Y., Palæontology, Vol. v, Pt. I, Lamellibranchiata, I, p. 177).	
Spirifera mesacostalis Hall	(r)
Pleurotomaria sp	(r)
Orthoceras sp	(rr)
Goniatites sp	(rr)

These fossils are from the lower part of what Prof. White has described and mapped as Chemung, and from the locality which is mentioned in his description of Stroud Township. The professor wrote: "Along the county road, about one-half mile below Spragueville, the Chemung rocks are seen in cliffs of gray fine-grained sandstone, quite fossiliferous."[3] The fauna is not that of the typical Chemung, but rather appears to be that of the Ithaca group which forms at Ithaca, N. Y., the middle of the Portage stage. Bearing upon this question is the statement of Prof. James Hall to the Geological Society at Rochester, that he believed "the Chemung formation went no farther east than Delaware County [New York]."[3] Prof. White mentions "*Spirifer disjunctus*"[4] as occurring in the Chemung of northeastern Pennsylvania. Very careful search was given to the rocks called Chemung, as well as to the overlying ones, yet no specimen of this well-known Chemung species was found. In places numerous specimens of *Spirifera mesastrialis* Hall were found, which on hasty examination might be mistaken for the typical Chemung species.

No. 1475 C7.—On the third hill below Spragueville, to the east of the

[1] Proc. Am. Asso. Adv. Science, Vol. XXXVI, p. 210.
[2] G[6], p. 272.
[3] As reported in the Rochester Post Express, August 16, 1892.
[4] Ibid., p. 105.

road, are found ledges of sandstone, containing numerous specimens of winged Lamellibranchs (? *Actinopteria* cf. *boydi*), which weather to a light gray color, but are bluish on a fresh fracture. This may be the "coarse yellowish-gray sandstone" mentioned by Prof. White as occurring 200 feet below the top of the Chemung, near Sprague ville.[1]

FAUNA OF NO. 1475 C7.

Tropidoleptus carinatus (Con.) Hall ..... (rr)
Spirifera mesacostalis Hall ..... (rr)
Homalonotus dekayi (Green) Emm ..... (rr)
Paracyclas lirata (Con.) Hall ..... (rr)
(?) Actinopteria cf. boydi Hall ..... (c)
Palæoneilo emarginata (Con.) Hall var ..... (rr)
Rhynchonella sp ..... (r)
Nuculites sp ..... (rr)

No. 1475 C8.—Exposures of sandstone and shales near the summit of the second hill below Sprague ville, on eastern side of the road. On the southern side of the ridge toward the summit is a ledge of rather massive sandstone. A little higher are shaly layers, some of which cleave very smoothly, and in these shales are some fossils. Lamellibranchs are most abundant, but *Spirifera mesastrialis* Hall is also present. The fossils only occur in a thin layer in shales that are generally nonfossiliferous.

FAUNA OF NO. 1475 C8.

Nuculites oblongatus Con ..... (a)
Paracyclas lirata (Con.) Hall ..... (c)
Palæoneilo plana Hall ..... (aa)
Prothyris lanceolata Hall ..... (r)
Microdon (Cypricardella) gregarius Hall (?) ..... (r)
Palœoneilo emarginata (Con.) Hall var ..... (c)
There are small specimens, which are apparently the same as the small shell figured by Prof. Hall on pl. 50, fig. 11, from Ithaca as this species. But there are larger specimens of this form, and these differ from P. emarginata in having the posterior margin only slightly sinuate, instead of deeply, and the umbonal slope is faint, forming a shallow depression which nearly disappears toward the umbo. This character is very marked when compared with the typical P. emarginata with its conspicuous emargination. However, the shell is decidedly of the P. emarginata type, and although some authors might regard the variation as of specific rank, I prefer to call it only varietal.
Nuculites cf. cuneiformis Con ..... (c)
The specimens are higher than most of Nuculites (except fig. 16, pl. 47) and in proportions suggest Goniophora; but they possess a clavicular ridge and teeth, and so are clearly Nuculites. There are smaller specimens associated with the larger, which are probably the young, as suggested by Dr. Charles E. Beecher.
Leda diversa Hall ..... (rr)
Cf. Prothyris planulata Hall and Orthonota carinata Hall ..... (rr)
Difficult to decide to which of these species the two specimens belong.
Orthonota (?) parvula Hall (?) ..... (rr)
Poorly preserved specimen.

[1] G[6], p. 272.

Spirifera mesastrialis Hall	(c)
Spirifera mesacostalis Hall	(rr)
Nucula corbuliformis Hall	(rr)
Orthonota undulata Con	(rr)
Tentaculites sp	(rr)
Lingula sp	(rr)
Orthoceras sp	(rr)
Pleurotomaria or Cyclonema sp	(rr)

The rocks from which the above fauna was obtained are a typical exposure of those which have been called Chemung by Prof. I. C. White in eastern Pennsylvania. In describing this exposure Prof. White said: "Along the county road, about one-half mile below Spragueville, the Chemung rocks are seen in cliffs of gray fine-grained sandstone, quite fossiliferous;"[1] and in his account of the geologic formations he further stated that: "It was impossible to identify any of the beds between the base of the Catskill and the top of the Hamilton with the Portage series of other portions of Pennsylvania, either on lithological or palæontological grounds, and hence I have applied the name Chemung to the entire interval, preferring to regard the Portage series as absent from this district."[2] Several reasons are given for this correlation, that of first importance being "the occurrence of characteristic Chemung fossils throughout the entire interval."[3] Later, in describing the geology of the Susquehanna River region, Prof. White stated that probably the beds in the lower part of the Chemung "are the equivalents of the Portage beds in New York;"[4] and in a letter dated February 22, 1892, emphasizes the fact that he wishes the above statement to apply to Monroe and Pike Counties, and that the lower part of the terrane called Chemung in those counties corresponds to the Portage of New York.

The fauna of this formation is not characteristic of the Chemung stage of southern, central, and western New York, or even of the highest fossiliferous pre-Carboniferous rocks of southern Pennsylvania and western Maryland. On the contrary, it is a modified Hamilton fauna, similar to the faunas that occur in central and eastern New York in the Portage, especially after the Tully limestone and Genesee shale have disappeared. It hardly seems to be so late as the "Ithaca group," but rather approaches the earlier modified stages of the Hamilton fauna, as possibly the *Paracyclas lirata* stage of Dr. H. S. Williams, which is found well developed above the horizon of the Genesee shale at Oneonta and Norwich in central New York.[5]

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[1] G [6], p. 272.

[2] Ibid., p. 104.

[3] Ibid., p. 104.

[4] G [7], 1883, p. 68; and see pp. 70 and 228 for similar statements.

[5] See Prof. H. S. Williams in Proc. Am. Assoc. Adv. Sci., Vol. XXXIV, p. 225 and chart; and Prosser, ibid., Vol. XXXVI, p. 210. This fauna characterized the Oneonta group of Conrad (not Vanuxem, who applied the same name to the overlying gray and red sandstones and shales), which was composed of blush shales with some sandstones and abundantly fossiliferous. The zone is well exposed in the quarry at the foot of the hill west of Oneonta, at Norwich in the quarry near the reservoir, and in the lower part of the high hill west of the village. For Conrad's description of the "group" see Ann. Geol. Rept., N. Y., 1841, pp. 30, 31, 50, and 53.

It is true that *Spirifera disjuncta* Sow. is reported from this formation;[1] and if the specimens were correctly identified that would be almost conclusive proof of its Chemung age. But the writer has failed to find this species on the eastern side of the Pocono and Catskill mountains and is inclined to think that *Spirifera mesastrialis* Hall, an allied species which is not uncommon, is the one reported for *S. disjuncta*, especially since the Cascade section of Susquehanna County, Pa., has been reported to contain well-known Chemung shaly and flaggy strata full of *Spirifera disjuncta*.[2] When the section was examined, in company with Dr. H. S. Williams, it was found that the common species was *S. mesastrialis*, which had evidently been mistaken for the *S. disjuncta*.[3]

After considerable field work in southeastern New York and northeastern Pennsylvania, the conclusion is reached that the marine faunas terminated either slightly in advance or soon after the appearance of the Chemung stage. In central and southern Pennsylvania and western Maryland the conditions seem to have been more favorable, and *Spirifera disjuncta* with other Chemung species occurs in rocks which are stratigraphically equivalent to the unfossiliferous beds farther toward the northeast. The geological collections of Johns Hopkins University contain a few specimens of *Spirifera disjuncta* from near Cumberland, Md.,[4] and Profs. Claypole,[5] White,[6] Stevenson,[7] Ashburner,[8] and Meek[9] have reported the species from a number of localities in Pennsylvania and Virginia.

The shales and sandstones of the Chemung series, which contain the highest fossil shells seen by Prof. White, are succeeded by greenish-gray, thick-bedded sandstones—the Starucca sandstone of Prof. White—which at that time he considered the base of the Catskill.[10] Later, Prof. White states "it seems probable that the 600 feet of grayish-green beds at the top of the Chemung in Pike and Monroe, which in G6 were referred to the Catskill under the name of Starucca beds, may be the equivalent of a portion of the Upper Chemung of this district [Susquehanna River region], and therefore erroneously referred to the

[1] G6 p. 105.

[2] G5, p. 78.

[3] See the remarks on the Cascade section by Dr. Wllilams, who states: "When I examined the section I found no trace of several of the species cited, and only rare and imperfect specimens of *Spirifera disjuncta* and the last stage with *Rhynchonella contracta*; but all the mass of the fauna was *Spirifera mesastrialis* and its legitimate associates, which is a lower fauna belonging to the more eastern part of this general area. The difference between the two *Spiriferas* appears at first glance slight; but they are clearly distinct." (Proc. Am. Assoc. Adv. Sci., Vol. xxxiv, p. 231).

[4] See list of Chemung fossils from Maryland, by Charles R. Keyes, in Johns Hopkins Univ., circulars, Vol. xi, December 1891, p. 29, which specimens, through the courtesy of Dr. W. B. Clark, have been personally examined.

[5] F2, pp. 74, 77, 289, 291.

[6] T3, pp. 98, 183, 194.

[7] T2, pp. 76, 80. 133, 212, 214, 216, 225, 226; and Amer. Geol., Vol. ix, pp. 10, 26.

[8] F, pp. 221, 225.

[9] Bull. Phil. Soc. Washington, Vol. ii; Appendix, art., viii, p. 34.

[10] G6, pp. 102, 103. See G5, 1881, pp. 59, 70, 73, and fig. 10 on p. 77 for the original description of this zone.

Catskill in G6."[1] In the letter mentioned above Prof. White writes that 600 feet of sandstones, which in G6 were put in the Catskill, should be added to the Chemung. Referring to the difficulty in separating the Chemung and Catskill, the professor says: "I think the only possible separation of Chemung and Catskill is that founded upon physical characteristics, and in my opinion we should separate them at the horizon of the lowest red beds, for these seem to come in at about the same general zone everywhere, and it is the only possible means of separation." These sandstones are well exposed at Spragueville and in the Delaware, Lackawanna and Western Railroad cut just north of the station. In this cut is a layer of red shale, in the midst of the sandstone, which is the first or lowest red bed seen in the section.

The second railroad cut, just north of the Brodhead Creek railroad bridge, is in the New Milford red shale, which is now regarded by Prof. White as forming the base of the Catskill.[2] The red shales alternate with gray shales and sandstones as far as the "High Bridge" over the west branch of Brodhead Creek, when the Delaware River flags of White are reached.[3] These flags do not consist entirely of gray shales and sandstones, but reds alternate with the grays.

No. 1475 E2.—At the southern end of the first railroad cut north of the "High Bridge," a slab of greenish-gray sandstone was found which contained many impressions of *Orthonota (?) parvula* Hall,[4] a species which occurs in the upper Hamilton shales of Schoharie County, N. Y., as well as frequently in the argillaceous Hamilton shales of central and western New York. There is also a calcareous (?) breccia which contains fragments of Brachiopod shells, as *Spirifera* sp., and fish bones. The dip in the cut is more than 20° north. The rocks of the railroad cut are red, gray, and greenish shales, alternating with sandstones. At the northern end of the cut, near the sign "whistle," are coarse, grayish, arenaceous shales in which fern stipes occur, and one poorly preserved frond of *Archæopteris minor* Lx. (?) was found.

No. 1475 E1.—A short distance south of the Henryville Station is a railroad cut through the red shale which is called the Montrose red shale by Prof. White.[5] The dip is about 14°, between 20° and 25° west of north. In the red shale of this cut Prof. White reported "vast numbers of fronds of *Archæopteris Jacksoni*."[6]

In another place the rarity of fossils in the Catskill is commented upon and the importance of this locality noted as follows: "Plant

[1] G[7], p. 73.
[2] G[6], pp. 101, 273.
[3] G[6], p. 100.
[4] The first published reference to this discovery is in the Amer. Geol., Vol. ix, p. 15, footnote. Dr. Charles E. Beecher has seen these specimens and agrees with the above identification. Dr. J. M. Clarke has kindly compared some of the specimens with the types in the New York State Museum at Albany, and writes: "I see no reason why the shells in question should not be regarded as *Orthonota (?) parvula*, in accordance with your identification; I have compared them with the types of *O.(?) parvula* and can find no distinctive characters."
[5] G[6], pp. 320, 98.
[6] Ibid., p. 320.

remains are of very rare occurrence, the only locality in the district where any determinable forms were seen being a short distance below Henryville in a cut on the Delaware, Lackawanna and Western Railroad. There, near the base of the Montrose red shale, great numbers of *Archæopteris Jacksoni* occur."[1]

Careful search failed to reveal a fragment of an *Archæopteris*, and the only fossils seen were the irregular fucoidal (?) markings that are frequently found in the red shales of the Upper Devonian.

No. 1475 F1.—Near the southern end of the second railroad cut north of Henryville, in green argillaceous shale, just on top of red shale, a fragment of a brachiopod shell was found. At the northern end of the cut, in greenish, somewhat arenaceous shales, 1½ feet above red shale, are fossils. The cut shows one of the small rolls that were frequently noticed along the line of the railway. These rocks are probably in the formation called "the Honesdale sandstones" by Prof. White, although near the transition from them to the underlying Montrose shale. Above this horizon no fossils were seen in the higher rocks, except indeterminable fragments of plants, and this is the highest fauna that has yet been found in Monroe and Pike Counties.

FAUNA OF NO. 1475 F1.

Spirifera mesacostalis Hall.

Ten specimens, part of them broken, from a thin layer of greenish, moderately arenaceous shale. It is the only fossiliferous stratum seen in these beds. Five specimens in good condition were found, so there is no doubt as to their specific identification.

Leda diversa Hall (?).

Possibly the specimen is L. brevirostris Hall, since it is not so long as the typical L. diversa, but on the contrary it is not so high as the typical L. brevirostris.

Spirifera mesastrialis, which is reported from the Hamilton of Schoharie County, N. Y.,[2] is an abundant and well-known species of the middle zone of the "Ithaca group" at Ithaca, and is also found in the lower Chemung, farther south in southern central New York,[3] and northern Pennsylvania,[4] while *Leda diversa* is a Hamilton species of eastern and central New York. The fossils seem to indicate that these shales are hardly younger than the lower Chemung and they might be still older, since the specimens of *Spirifera mesastrialis* do not appear to be the variety which is found in the lower Chemung of southern New York; but, on the contrary, the form found in the older rocks of the Portage.

The nearest correlation to the above is that of Prof. Stevenson in his vice-presidential address before Section E of the American Association, in 1891, when he drew the line separating the Catskill from the

[1] G[6], p. 103.

[2] Geol. Survey N. Y., Palæontology, Vol. IV, Pt. I, p. 417.

[3] Bull. U. S. Geol. Surv., No. 3, pp. 17, 22, 24.

[4] Proc. Am. Asso. Adv. Science, Vol. XXXIV, p. 231.

Chemung, between the Montrose sandstone above and the Montrose red shale below,[1] which is at a part of the series not distant from the horizon in which the *Spiriferas* were collected above Henryville.

Above this horizon coarse, gray sandstones and shales alternate with reddish shales. A thick mass of the red shale is well exposed in the railroad cut just west of Oakland. The cut below Mount Pocono shows coarse, gray sandstone with fragments of fossil plants, thin, bluish, argillaceous shales, breccia, and red shales, while in places the coarse, gray sandstone contains quartz pebbles, and is probably near the horizon of Prof. White's Cherry Ridge conglomerate, about 500 feet below the top of the Catskill.[2]

In general structure and lithologic appearance, these rocks are very similar to the typical Catskill of the Catskill Mountains.

On the summit of the Pocono plateau, about 2½ miles north of Tobyhanna, is a massive conglomerate which is considered by Prof. White as the Mount Pleasant conglomerate at the base of the Pocono.[3]

POCONO CREEK AND POCONO KNOB SECTION.

After the section along the line of Brodhead Creek and the Delaware, Lackawanna and Western Railroad had been studied, another one was made from Stroudsburg along Pocono Creek, through Bartonsville and Tannersville to Pocono Knob. The same series of formations was crossed by this latter section as by the former; but in general the exposures are not so good, and the conditions not so favorable for a careful study of the stratigraphy and palæontology of the region. However, the general results were about the same, as will be seen from the lists of fossils and descriptions of different localities.

No. 1475 D—2.—On the highway from Stroudsburg to Bartonsville, a little below the Tanite Company's mill, is an outcrop of bluish, arenaceous shale, which is quite fossiliferous, *Tellinopsis subemarginata* (Con.) Hall, being the most abundant species.

FAUNA OF NO. 1475 D—2.

Tellinopsis subemarginata (Con.) Hall	(aa)
Spirifera mucronata (Con.) Bill	(rr)
Leiorhynchus multicosta Hall	(rr)
Amboccelia umbonata (Con.) Hall	(rr)
Chonetes lepida Hall	(rr)
Chonetes sp., probably C. setigera Hall, although two specimens approach C. scitula Hall in form	(c)
Palæoneilo constricta (Con.) Hall	(rr)
Lunulicardium fragile Hall	(r)
Lingula sp.	(rr)
Orthoceras sp.	(r)
Actinopteria cf. muricata Hall	(rr)

[1] Am. Geol., Vol. IX, p. 14.
[2] G[6], p. 78.
[3] G[6], pp. 90, 329.

No. 1475 D—3.—Down the bank, just opposite the Tanite works, by Pocono Creek, the shales are blue and more arenaceous than those by the roadside.[1]

FAUNA OF NO. 1475 D—3.

Amboccelia umbonata (Con.) Hall ..... (r)
Chonetes mucronata Hall ..... (r)
Dalmanites boothi (Green) Hall (?) ..... (rr)

The lithologic character of the shales and the fauna show that these exposures are typical Hamilton rocks.

No. 1475 D1.—Exposures along Pocono Creek, just north of the covered bridge at Bartonsville. The dip is about 12° and the direction 25° west of north. The ledges consist of sandstones, frequently of irregular bedding with an approach to concretionary structure, similar to those along the highway below Spragueville, and a little above the railroad crossing, alternating with somewhat bluish shales, and varying from 1 to 2 feet in thickness. The small concretions in the shales usually contain fossils. Nearly all the fossils are small forms which occur sparingly in the shales, more frequently on the surface of the sandstones, but are most common in the shaly arenaceous layers.

FAUNA OF NO. 1475 D1.

Tropidoleptus carinatus (Con.) Hall ..... (rr)
Paracyclas lirata (Con.) Hall ..... (r)
Spirifera mesacostalis Hall ..... (a)
Chonetes setigera Hall (?) ..... (aa)
Part of the specimens are very near to the form of this species found in the "Ithaca group" at Ithaca, N. Y.; others are in some of the characters suggestive of C. lepida Hall, there being two rather stronger ribs and in one specimen five intermediate ones; while a few specimens have the elongated form of C. scitula Hall, but they do not have the numerous plications of that species.
Leda diversa Hall ..... (rr)
Rhynchonella stephani Hall ..... (c)
Leiorhynchus mesacostalis Hall ..... (rr)
Nuculites oblongatus (Con.) Hall (?) ..... (rr)
Distorted, but pretty surely this species.
Microdon (Cypricardella) bellistriatus (Con.) Hall ..... (rr)
Modiomorpha subalata (Con.) Hall, var. chemungensis Hall (?), broken and distorted specimens which closely resemble this variety ..... (r)
Actinopteria cf. boydi (Con.) Hall ..... (rr)
Pleurotomaria sp ..... (rr)
Platyceras sp ..... (rr)
Spirifera sp., large impressions imperfectly preserved which may be compared with S. mesastrialis ..... (rr)

This fauna occurs in what was called "Chemung" by Prof. White, and corresponds to the exposures along the highway below Spragueville and to those above the railroad crossing.

[1] This exposure is mentioned by Prof. White, who says: "Just opposite the Tanite Company's works, a bluff of Hamilton rocks, 65 feet high, rises almost vertically from the bed of Pocono." G6, p. 271.

No. 1475 D—1.—Hill southwest of Bartonsville, perhaps a half mile, is composed of coarse arenaceous shales in which fossils are very rare.

As stated by Prof. White, the greenish gray sandstones of the Starucca appear about 1 mile above Bartonsville,[1] and then sandstones and red shales alternate along the road until Tannersville is reached.

No. 1475 D2.—The abrupt southeast side of Pocono Knob, northwest of Tannersville, is composed of red, arenaceous shales, No. 4 of Prof. White's Pocono Knob section.[2]

This shale belongs in the professor's "Cherry Ridge" group, and is in the upper part of his Catskill series. The arenaceous shale contains broken pieces of the fucoid (?) which is frequently found in the red arenaceous shales and sandstones of New York and Pennsylvania. Several specimens were seen on the talus below the brow of the knob.

No. 1475 D3.—Above the shale is a conglomerate layer (White's lower conglomerate) followed by reddish sandstone and arenaceous shale, and then the upper conglomerate, which is a very massive stratum, containing quartz pebbles, and pebbles of the red and blackish shale. Prof. White reports "many fish fragments" from near the base of the lower conglomerate (No. 3 of the knob section);[3] but they were not found in my hasty examination of this locality.

LEHIGH RIVER SECTION.

In connection with the sections along the Delaware, Lackawanna and Western Railroad, and the Pocono Creek through Bartonsville and Tannersville, it is interesting to compare one, farther southwest along the Lehigh River through Weissport and Bowmans station.

Prof. White's geological map of Pike and Monroe counties[4] extends southwest of Monroe County into Carbon County and across the Lehigh River. Later, Arthur Winslow constructed a section from Wilkesbarre to the Lehigh Gap, mainly along the Lehigh River; and accompanying the report is a map, showing the geological formations along the line of the section.[5]

On Prof. White's map, Weissport is shown as situated mainly on an anticlinal of Hamilton rocks, just reaching the edge of the Genesee; the Chemung being exposed still farther to the southeast. In describing the distribution of the Genesee shale, Prof. White states that one band reaches the Lehigh River, a short distance above Lehighton Station on the Central Railroad of New Jersey, and another crosses the river just below Lehighton Station on the Lehigh Valley Railroad.[6]

The above description is repeated by Prof. Lesley in his final report.[7]

Mr. Winslow colored all of the central part of the anticlinal fold as

[1] G^6, p. 103.
[2] G^6, p. 315.
[3] G^6, p. 316.
[4] Accompanying the geology of Pike and Monroe counties. 2d Geol. Surv. Pa. G^6.
[5] Ibid., An. Rep., 1886, Pt. IV, the Lehigh River cross-section, p. 1331.
[6] G^6, p. 108.
[7] Sum. Desc. Geol. Penn., Vol. II., p. 1327.

Genesee shales flanked by the Chemung and Portage. In describing this outcrop Mr. Winslow said: "South of Lock No. 7, the Genesee shales are exposed for over a mile to below Lock No. 9 at Weissport. Their fissile and broken character is well shown here; in places they are so black that the rock looks more like weathered coal or highly carbonaceous shale,"[1] while it is further stated that "shells are numerous in the Chemung and Genesee outcrops (VIII) near Weissport.[2]" The thickness of the Genesee is given as 200 feet by Prof. White on the Lehigh River,[3] and the Hamilton as 760 feet.[4]

The exposures at Lehighton and Weissport were carefully studied, after the Hamilton of Pike and Monroe counties, Pa., and eastern New York had been examined, in order to determine whether the zone called the Genesee of that region agreed any more closely with the Genesee of New York, than the beds of northeastern Pennsylvania, which had been referred to that stage. A highway cut, No. 1481 A 1, opposite the bridge across the Lehigh River between Weissport and Lehighton, and just below the Lehighton Station of the Lehhigh Valley Railroad, affords an excellent opportunity to study the so-called Genesee of that region. The exposure consists mainly of bluish to bluish-black, argillaceous shales, which contain fossils in considerable abundance. In lithologic character, the deposit agrees closely with the similar zone further to the northeast; but the fauna is not that of the Genesee shales but of the argillaceous Hamilton shales as will be seen by referring to the list of species; some of the most common forms being *Spirifera mucronata* (Con.) Bill., and *Tropidoleptus carinatus* (Con.) Hall. A short distance up the street and under the blackish shale is a stratum with large numbers of Bryozoa, Crinoidal stems etc., similar to the zone called the "Tully limestone" on the Bushkill creeks. The highway cut, through this argillaceous shale was made in 1890 when the river bridge was built, and is just above the exposure on the Lehigh Valley Railroad which was described by Prof. White as the Genesee.[5]

FAUNA OF No. 1481 A1.

Spirifera mucronata (Con.) Bill.	(aa)
Spirifera fimbriata (Con.) Hall	(rr)
Tropidoleptus carinatus (Con.) Hall	(c)
Chonetes mucronata Hall (?)	(a)
Homalonotus de kayi (Green) Emm	(r)
Phacops rana (Green) Hall	(rr)
Dalmanites (Cryphæus) boothi (Green) Hall	(rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall	(rr)

[1]Sum. Desc. Geol. Penn., Vol. II, p. 1371.

[2]Ibid., p. 1385.

[3]G[6], pp. 80, 81: On page 109 it is stated that "the thickness of the group [Genesee] seems to remain constant at about 200 feet, from the eastern line of the district clear through to the Lehigh River in Carbon County."

[4]Ibid., pp. 80, 81.

[5]G[5], p. 108.

Macrodon hamiltoniæ Hall (?) ..... (rr)
Strophodonta perplana (Con.) Hall (?) ..... (rr)
Orthis vanuxemi Hall (?) ..... (rr)
Chonetes coronata (Con.) Hall ..... (rr)
Rhynchonella sappho Hall (?) ..... (rr)
Michelina (Pleurodictyum) stylopora (Eaton) Hall (?). The specimens are like Pleurodictyum problematicum Goldf. which is regarded as a Michelina ..... (rr)
Cf. Striatopora (Thamnoptychia) limbata (Eaton) Hall ..... (c)

It will be noticed that all these fossils are Hamilton species and there is no more reason for regarding this zone as belonging to the Genesee, than the one further northeast, of which this is the southwestern continuation. Mr. Winslow was correct in regarding the exposures at Lehighton and Weissport as of the same geologic age, with some difference in lithologic character, but the fossils show that the geologic age is Hamilton instead of Genesee.

No. 1481 A2.—Exposures in southern part first railroad cut north of Bowmans Station on the Lehigh Valley Railroad. The shales are of blackish to bluish-black color, quite fossiliferous and somewhat slaty, due to the folding which has also distorted the fossils. *Spirifera mucronata* Hall (?) and *Phacops rana* (Green) Hall are common fossils. This is the outcrop mentioned by Prof. White as "about 30 rods above Bowmans Station,"[1] which was called Genesee, in which correlation he was followed by Winslow and Hill[2] and which is accepted by Prof. Lesley in his final report.[3]

FAUNA NO. 1481 A2.

Spirifera mucronata (Con.) Bill ..... (aa)
Chonetes coronata (Con.) Hall ..... (rr)
Chonetes mucronata Hall (?) ..... (a)
The specimens are nearly twice the size of the ordinary ones of this species, and on one specimen the spines do not appear to extend parallel to the hinge line.
Strophodonta perplana (Con.) Hall (?) ..... (rr)
Cyrtina hamiltonensis Hall ..... (rr)
Michelina (Pleurodictyum) stylopora (Eaton) Hall ..... (c)
Dalmanites (Cryphæus) boothi (Green) Hall ..... (r)
Phacops rana (Green) Hall ..... (rr)
Homalonotus de kayi (Green) Emm ..... (rr)
Nucula corbuliformis Hall (?) ..... (rr)

It will be seen that, like all the other so-called "Genesee" horizons, the fossils show this to be of Hamilton age.

Farther north in the cut is a rather calcareous stratum which contains large numbers of shells, as *Orthis*. This is probably the same horizon

[1] G[6], p. 108.

[2] An. Rep. 1886, Pt. IV, p. 1374, where it is stated that "only 125 feet of these shales [Genesee] are exposed on the north side of the anticlinal fault at Lock No. 14. They are quite like the shales which rise on each side of the anticlinal near Weissport;" and see Winslow's cross section of this region.

[3] Sum. Desc. Geol. Penn., Vol. II, p. 1327; where is the statement that the Genesee occurs "about 30 rods above Bowman's."

as the one generally called the Tully limestone by the Pennsylvania geologists.

The above description of the Lehigh section shows that there is no more evidence in favor of the correlation of this argillaceous zone of the Hamilton stage with the Genesee stage of New York than was found for the same zone in Pike and Monroe counties and southeastern New York. The fossils are not Genesee but Hamilton species, and, moreover, the lithologic characters are not those of the Genesee shale, but those of the black argillaceous zones of the Hamilton, as, for instance, the Moscow shale immediately below the Tully limestone. After making the long sections along the Delaware, Lackawanna and Western Railroad and Pocono Creek, the Devonian rocks were followed northeasterly through Monroe and Pike counties, Pa., and across the Delaware River into New York. Numerous shorter sections were made along the gorges of the various creeks, across rocks of Middle and Upper Devonian age. The first of these local sections is along Marshall Creek, the nearest creek of any size to the east of Brodhead Creek.

MARSHALLS CREEK SECTION.

No. 1476 A1.—An exposure of blue, moderately arenaceous shale by roadside about one-half mile north of Marshalls Falls post-office, and only a few rods south of the entrance to Marshalls Falls. The fossils are common, mainly Hamilton, with a few Marcellus species, while the most common form is *Leiorhynchus multicosta*, Hall (?). A little farther up the road, about opposite the house, the shales are coarser, with a larger number of species, and these are all Hamilton fossils.

FAUNA OF NO. 1476 A1.

Leiorhynchus multicosta Hall (?)	(aa)
The specimens are all rather small and must be compared with fig. 26, Pl. 56 (Geol. Surv. N. Y., Palæontology, Vol. IV, Pt. I) of the above species, which is stated to be a young shell. There does not seem to be a specific difference between these and the specimens from the Marcellus shale of No. 1475 B1, which are L. limitaris (Van.) Hall.	
Ambocœlia umbonata (Con.) Hall	(a)
Modiella pygmæa (Con.) Hall	(r)
Nuculites oblongatus Con	(rr)
Nucula corbuliformis Hall	(a)
Nuculites triqueter Con	(r)
Palæoneilo constricta (Con.) Hall (?)	(rr)
Specimen badly crushed and distorted.	
Grammysia constricta Hall	(r)
Chonetes scitula Hall (?)	(c)
Chonetes lepida Hall	(r)
Chonetes mucronata Hall	(rr)
Lingula sp., a broken specimen with a strong median impression, cf. L. alveata Hall, but in proportions it is nearer L. delia Hall	(rr)
Orthoceras subulatum Hall (?)	(rr)
Leiopteria lævis Hall	(rr)

Actinopteria muricata Hall (?) ..... (rr)
This may be a small specimen of A. boydi (Con.) Hall, for it is broken, and according to the descriptions these species have similar markings, but A. boydi is a large species and this specimen is small.
(?) Leiopteria cf. gabbi Hall ..... (rr)
Loxonema sp ..... (rr)

No. 1476 A2.—Marshalls Falls, on Marshalls Creek, one-half mile north of Marshalls Falls post-office. The entire exposure is apparently Lower Hamilton. Prof. White says, "The stream has cut a narrow gorge at the base of the Hamilton only 5 to 8 feet wide, through which it falls into a large amphitheater hollowed out of the soft Marcellus beds below."[1] It is true that in the blue shales below the falls fossils are not nearly so abundant as they are farther up the bluff, but those that do occur are Hamilton species. In the amphitheater below the falls *Vitulina pustulosa* Hall occurs in the shales just at the water's edge, and this is a well-known Hamilton species. In the fine shales of the bluff forming the lower portion of the falls the smaller forms of characteristic Hamilton fossils are quite abundant. Above the brink of the falls the rock is more coarsely arenaceous, and in this *Spirifera granulifera* Hall (?) and similar species occur. Prof. White says, "At the head of the falls numerous fossils were observed, among which were *Spirifer granuliferus*, *Grammysia bisulcata*, *Athyris spiriferoides*, besides numerous crinoidal stems."[1]

FAUNA OF NO. 1476 A2—(FROM THE EDGE OF WATER BELOW MARSHALLS FALLS).

Vitulina pustulosa Hall ..... (rr)
Chonetes mucronata Hall (?) ..... (rr)
Rather poorly preserved specimens and not safe to identify them positively.
One specimen of a smooth impression which looks as though it might be a fragment of an algoid frond. Similar impressions were seen at several localities in the Hamilton shales of northeastern Pennsylvania.

FAUNA OF NO. 1476 A2.

Vitulina pustulosa Hall ..... (aa)
Amboccelia umbonata (Con.) Hall ..... (rr)
Spirifera mucronata (Con.) Bill ..... (a)
Spirifera granulifera Hall (?) ..... (rr)
Possibly S. medialis Hall, but there is a strong furrow in the mesial fold.
Tellinopsis subemarginata (Con.) Hall ..... (rr)
Phacops rana (Green) Hall ..... (c)
Dalmanites boothi (Green) Hall (?) ..... (r)
Chonetes lepida Hall ..... (rr)
Chonetes deflecta Hall (?) ..... (c)
Chonetes mucronata Hall (?) ..... (a)
Part of the above specimens are undoubtedly C. mucronata and thence they grade up to typical C. deflecta. These and specimens from other localities seem to prove Prof. Hall's suspicion that C. deflecta is only a larger form of C. mucronata (Geol. Surv. N. Y. Palæontology, Vol. IV. Pt. I, p. 126).

[1] G[6], p. 255.

Paracyclas lirata (Con.) Hall ..... (rr)
Nuculites triqueter Con ..... (rr)
Nucula bellistriata (Con.) Hall (?) ..... (rr)
Specimen broken, but there is little doubt as to its identification.
Streptorhynchus chemungensis (Con.) Hall var. arctostriata (?) ..... (rr)
Strophodonta perplana (Con.) Hall ..... (rr)
Productella sp. possibly P. truncata Hall. The specimen is broken, but the umbo of the dorsal valve is slightly truncate ..... (rr)
Hyolithes aclis Hall ..... (r)
Pholadella radiata (Con.) Hall (?) ..... (rr)
Lunulicardium fragile Hall ..... (rr)
Palæoneilo constricta (Con.) Hall ..... (rr)
Pleurotomaria sulcomarginata Con. (?) ..... (rr)
An internal impression which closely resembles fig. 16, Pl. XIX of this species (Geol. N. Y. Palæontology, Vol. IV, Pt. I).
Coleolus tenuicinctum Hall (?) ..... (rr)
Grammysia sp ..... (rr)
Bryozoa ..... (r)

Further up the creek were loose shales in which additional species of fossils were found; also some shales of somewhat different lithologic character containing fragments of fossil plants, which closely resemble *Psilophyton princeps* Dn.

FAUNA OF NO. 1476, A2+ (UP MARSHALLS CREEK ABOVE THE FALLS).

Ambocœlia umbonata (Con.) Hall ..... (r)
Cimitaria recurva (Con.) Hall ..... (rr)
Hyolithes aclis Hall ..... (rr)
Athyris spiriferoides (Eaton) Hall ..... (rr)
Spirifera mucronata (Con.) Bill ..... (rr)
Modiomorpha mytiloides (Con.) Hall (?) ..... (rr)
Two broken specimens which may be M. concentrica (Con.) Hall.
Coleolus tenuicinctum Hall ..... (rr)
Psilophyton princeps Dn. (?) ..... (r)
The specimens are fragmentary in an arenaceous shale and possibly are only fern stipes. It is very difficult to identify such fragmentary remains of fossil plants, and on that account their evidence is of very little value. The custom of the older paleobotanists seems to have been very generally to describe such remains, when from different localities or formations, as new species. In this way the list of so-called species of fossil plants has attained great dimensions, the number of which is being most industriously increased by some students of paleobotany.

No. 1476 A7.—By the roadside above the Yedder schoolhouse, rather coarse arenaceous shales which correspond to the typical, moderately coarse, arenaceous Hamilton shales of Hamilton, N. Y., and contain plenty of fossils.

FAUNA NO. 1476 A7 (ALONG THE HIGHWAY ABOVE MARSHALLS FALLS).

Palæoneilo constricta (Con.) Hall ..... (r)
Another specimen, which is broken, is quite elongate and resembles somewhat P. plana Hall.
Leda diversa Hall ..... (rr)
Tropidoleptus carinatus (Con.) Hall ..... (rr)

Nucula corbuliformis Hall ..... (r)
Microdon (Cypricardella) bellistriatus (Con.) Hall ..... (rr)
Ambocœlia umbonata (Con.) Hall ..... (rr)
Atrypa reticularis (Linné) Dalm. ..... (rr)
Athyris spiriferoides (Eaton) Hall ..... (rr)
Spirifera granulifera Hall (?) ..... (c)
Specimens not well preserved and scarcely any indication of the granules.
Spirifera medialis Hall (?) ..... (r)
Grammysia bisulcata (Con.) Hall ..... (rr)
Prothyris planulata Hall ..... (rr)
Phthonia sectifrons (Con.) Hall ..... (rr)
Nuculites cuneiformis Con. (?) ..... (rr)
Pholadella radiata (Con.) Hall ..... (rr)
Leiopteria bigsbyi Hall (?) ..... (r)
Actinopteria boydi (Con.) Hall ..... (rr)
Modiomorpha sp., possibly M subalata (Con.) Hall ..... (rr)
Homalonotus de kayi (Green) Emm ..... (rr(
Hyolithes aclis Hall ..... (rr)
Phacops rana (Green) Hall ..... (rr)
Dalmanites boothi (Green) Hall ..... (r)
Chonetes lepida Hall ..... (rr)
Orthoceras nuntium Hall (?) ..... (rr)
Orthoceras sp. ..... (rr)
Rhynchonella sp. ..... (rr)
Pleurotomaria sp. ..... (rr)
Cyclonema sp. ..... (rr)
Discina sp. ..... (rr)
Strophodonta inequistriata (Con.) Hall ..... (rr)
A rather large specimen, but there are strong striæ, with intermediate finer ones, and it is near fig. 2 f, Pl. XVIII (Geol. N. Y., Palæontology, Vol. IV, Pt. I).

No. 1476 A6.—High ledges on hill east of Marshalls Creek and southeast of Miller's shop. The outcrop consists of rather coarse arenaceous bluish shales in which fossils are quite common.

FAUNA OF NO. 1476 A6.

Leiorhynchus mesacostalis Hall (?) ..... (c)
Possibly these specimens are L. globuliformis (Van.) Hall and they should be compared with specimens from Kattle Hill, in the Chenango River Valley, Broome County, N. Y.
Spirifera mesastrialis Hall ..... (rr)
Spirifera mesacostalis Hall ..... (rr)
Paracyclas lirata (Con.) Hall ..... (rr)
Tropidoleptus carinatus (Con.) ..... (r)
Chonetes lepida Hall ..... (c)
Chonetes setigera Hall ..... (r)
Orthis impressa Hall (?) ..... (rr)
Actinopteria cf. zeta Hall ..... (rr)
Actinopteria sp ..... (rr)
(?) Cladochonus sp ..... (r)

Prof. White, in describing the Chemung beds of Middle Smithfield Township, states that they are uncovered "in the vicinity of Miller's sawmill, where the creek makes a fall of 8 feet over them, and great

cliffs of the same are seen near the crest of the hill just below."[1] The exposure mentioned as "the crest of the hill" is evidently station 1476 A6; but it is an outcrop of moderately coarse arenaceous Hamilton shale, rather than of the so-called Chemung.

No. 1476 A5.—Ledges by the side of Marshalls Creek at H. Miller's house and shop, also a ledge forming a fall in the creek. Bluish arenaceous shale containing some fossils.

FAUNA OF NO. 1476 A5.

Leiorhynchus mesacostalis Hall	(c)
Some of the specimens show from two to four less prominent plications on each side of the mesial fold and sinus.	
Spirifera mesastrialis Hall	(r)
Spirifera mesacostalis Hall (?)	(c)
Some of the specimens resemble quite closely S. mucronata (Con.) Bill. and should be compared with the variety of this species from Chenango, N. Y., figured by Prof. H. S. Williams (Bull. Geol. Soc. Am., Vol. I, Pl. XII, fig. 13.	
Palæoneilo constricta (Con.) Hall	(rr)
Paracyclas lirata (Con.) Hall	(r)
(?) Palæoneilo tenuistriata Hall	(r)
Shell badly broken and identification doubtful.	
Chonetes sp	(rr)
Phacops rana (Green) Hall	(rr)

This is the locality mentioned by Prof. White as "the fall of 8 feet" which was cited above.

No. 1476 A4.—Ledges of bluish, arenaceous shale by roadside only a short distance south of Dead Mans Run, where the road forks not far above Miller's shop. The shales split up into thin layers and fossils are quite common.

FAUNA OF NO. 1476 A4.

Paracyclas lirata (Con.) Hall	(c)
Tropidoleptus carinatus (Con.) Hall	(rr)
Spirifera mesacostalis Hall	(rr)
Spirifera sp., probably S. mesastrialis Hall, but the specimens show scarcely any indications of fine striæ on the large plications	(a)
Leiorhynchus mesacostalis Hall	(rr)
Atrypa reticularis (Linné) Dalm	(rr)
Chonetes setigera Hall	(c)
Rhynchonella cf. stephani Hall	(rr)
Palæoneilo constricta (Con.) Hall	(rr)
Modiomorpha subalata (Con.) Hall var. chemungensis Hall (?)	(c)
Two of the specimens are larger than those figured by Prof. Hall, yet they seem to have the proportions of the variety rather than those of the species.	
Palæoneilo emarginata (Con.) Hall (?)	(rr)
Actinopteria boydi (Con.) Hall	(c)
Grammysia sp	(rr)
Leptodesma sp	(rr)
Pleurotomaria sp	(rr)

[1] G[6], p. 230.

No. 1476 A3.—At this point the lowest reds cross the road and run, and the ledge shows distinctly for some distance to the west. The red shale, which according to Prof. White is the New Milford red shale, has a thickness of about 56 feet as exposed in the road.[1]

A short distance farther north, on the western side of the road, is a ledge of bluish-gray sandstone, which has been worked to some extent for flagging stone. This is the J. Chamber's quarry, which is about 4 miles up Marshalls Creek from the post-office, and which was described by Prof. White and referred to the horizon of the Delaware flags.[1]

The sandstone is dipping 27° to the north, 20° to 25° west. No fossils were found except some fragments of plant stems.

SECTIONS OF THE BUSHKILL CREEKS.

No. 1476 C1.—Exposures in Saw Creek or Middle Bushkill, at Winona Falls. Most of the rock is a bluish arenaceous shale in which fossils are rare; but by the turn in the path opposite the third cascade, counting from the upper one down the stream, is a thin breccia-like layer in which fossils are abundant, and a few may be found in the blue, rather argillaceous shales inclosing the fossiliferous layer. The rocks about the Winona cascades are in Prof. White's Chemung.

FAUNA OF NO. 1476 C1.

Leiorhynchus mesacostalis Hall	(rr)
Rhynchonella cf. stephani Hall	(rr)
Chonetes lepida Hall	(r)
Chonetes scitula Hall (?)	(rr)
Actinopteria boydi (Con.) Hall	(c)
Nucula corbuliformis Hall	(rr)
Tentaculites cf. bellulus Hall	(rr)
Pleurotomaria sp	(rr)
(?) Modiomorpha sp	(rr)
Crinoid stems.	
Spirifera sp	(a)

Large specimens, with coarse, angular ribs, deep sinus, broad fold, no pustules, and scarcely any indication of fine secondary striæ. Owing to the imperfect preservation of the finer surface markings it is difficult to identify these specimens specifically.

No. 1476 C2.—Along the bluffs of Saw Creek, from the first falls below Winona to the second, are bluish, argillaceous shales in which some fossils occur. At places are layers containing large numbers of *Leiorhynchus multicosta* Hall.

FAUNA OF NO. 1476 C2.

Chonetes scitula Hall	(rr)
Spirifera mucronata (Con.) Bill	(r)
Leiorhynchus multicosta Hall	(c)

Some of the specimens approach L. mesacostalis Hall in absence of plications and form.

[1] G[6], p. 231.

Tropidoleptus carinatus (Con.) Hall ..... (rr)
Pholadella radiata (Con.) Hall ..... (rr)
Microdon sp ..... (rr)
Surface markings, so far as preserved, near M. gregarius Hall; but the proportions of the shell are nearer M. bellistriatus (Con.) Hall.
(?) Leptodesma sp ..... (rr)
Crinoid, stem, calyx, and arms, but poorly preserved ..... (rr)

No. 1476 C3.—Lower falls in Saw Creek over sandstones. This was called the base of the Genesee by Prof. White. In places it is quite calcareous and contains numerous fossils, *Orthis vanuxemi* Hall and others.

FAUNA OF NO. 1476 C3.

Orthis vanuxemi Hall ..... (c)
Phacops rana (Green) Hall ..... (rr)
Spirifera mucronata (Con.) Bill ..... (r)
Spirifera fimbriata (Con.) Hall ..... (rr)
Strophodonta inequistriata (Con.) Hall ..... (a)
Strophodonta perplana (Con.) Hall (?) ..... (rr)
Chonetes coronata (Con.) Hall (?) ..... (rr)
Athyris spiriferoides (Eaton) Hall ..... (rr)
Prothyris lanceolata Hall ..... (rr)
Bellerophon leda Hall (?) ..... (rr)
Small specimen, but with the markings of this species.
(?) Stictopora sp ..... (rr)

Prof. White presents a section of these falls under the heading of the "Middle Bushkill Falls section,"[1] and gives 50 feet of Genesee slate, then 15 feet of dark, hard sandstone, which forms the falls and which is stated to be "the lowermost portion of the Genesee."

No. 1476 C4.—Just under the falls is a stratum of rock which is largely composed of corals and *Syringopora*, and which reminds one somewhat of the crinoidal limestone of the New York Hamilton. The stratum comes up to the base of the sandstone above, and then stops, being exposed only on the eastern bank below the falls. This layer forms No. 3 of Prof. White's section,[1] and he states that it "marks the dividing line between the Genesee and the Hamilton proper. The whole 30 feet is one mass of corals, penetrating in every direction the dark bluish matrix. Many of the corals have been dissolved and leave the surface of the inclosing rock honeycombed and pitted in every manner conceivable. The species are very numerous and the individuals simply countless. This stratum doubtless marks the horizon of the Tully limestone of New York."

In the chapter on the "Description of the geological formations," under the heading of the "Tully limestone horizon," this locality is mentioned and the statement made that "probably the best exposure is at the falls of Middle Bushkill, 1½ miles above its junction with the Big Bushkill. Here it is a perfect mass of corals and shells for about 30 feet, a great number of species and genera being represented, among

[1] G[6], p. 213.

which the following were recognized: *Zaphrentis Rafinesquii*, *Z gigantea*, *Heliophyllum Halli*, together with several species of *Syringopora*, and other forms that I could not determine. This is by far the richest coral horizon in the district, being, in fact, a regular fossil reef. The calcareous portions of the coral stems have often been removed by solution, and then the matrix (usually a dark-gray calcareous shale) is penetrated by small branching cavities extending in every direction, thus giving it a honeycombed appearance."[1]

FAUNA OF NO. 1476 C4.

Favosites hamiltoniæ Hall	(c)
Amboccelia umbonata (Con.) Hall	(rr)
Spirifera mucronata (Con.) Bill	(rr)
Spirifera fimbriata (Con.) Hall	(rr)
Cypricardinia indenta (Con.) Hall	(rr)
Cyathophylloid corals, at least three species are abundant, permeating the rock in nearly every direction	(a)

No. 1476 C5.—This exposure is by the side of the new road on the northern side of the Big Bushkill, which extends westerly from Bushkill and intersects the north and south road which crosses the Big Bushkill and Saw Creeks. There are fissile grayish to dark blue shales in the cuts along this road, especially at the foot of the steep hill not far east of its junction with the north and south road; also at the eastern end, where the road turns down from the hill before crossing the Little Bushkill. All of them contain some fossils, *Leiorhynchus limitaris* (Van.) Hall being the most abundant. These shales are pretty clearly of Marcellus age.

FAUNA OF NO. 1476 C5.

Leiorhynchus limitaris (Van.) Hall	(aa)
Lunulicardium fragile Hall	(rr)

FAUNA OF NO. 1476 C5+(GRAYISH SHALES A LITTLE NORTHWEST OF THE BLUISH SHALES.

Leiorhynchus limitaris (Van.) Hall	(c)
Actinopteria muricata Hall	(rr)
Goniatites sp	(rr)

No. 1476 B1.—Bluish sandstones and shales in highway and by the side of Little Bushkill, where the highway crosses the creek above the falls, 3 miles north of Bushkill. The dip is from 14° to 16° to the north about 20° west. No fossils were found. Some of the ledges are rather grayish, split into thin layers, and somewhat resemble portions of the Starucca sandstone series. However, it is probably somewhat lower and in the so-called Chemung, as colored on the geological map of Pike and Monroe counties.

No. 1476 B2.—Upper portion of the blue arenaceous shales at Bushkill Falls, in the Little Bushkill Creek. Fossils are not very abundant in these shales.

[1] G[6]., p. 109.

FAUNA OF NO. 1476 B2.

Spirifera mucronata (Con.) Bill	(r)
Tropidoleptus carinatus (Con.) Hall	(r)
Nucula lirata (Con.) Hall (?)	(rr)
A small and imperfect specimen which agrees most closely with the above species.	
Spirifera fimbriata (Con.) Hall	(rr)
Nucleospira concinna Hall	(rr)
Ambocœlia umbonata (Con.) Hall (?)	
Microdon (Cypricardella) bellistriatus (Con.) Hall	(r)
Orthis vanuxemi Hall (?) or Orthis leucosia Hall (?)	(r)
Phacops rana (Green) Hall	(rr)
Cypricardinia indenta (Con.) Hall	(rr)
Actinopteria decussata Hall (?)	(rr)
Palæoneilo constricta (Con.) Hall	(rr)
(?) Bellerophon sp	(rr)

The rocks along the channel of the creek above these falls are called Genesee shales by Prof. White; but at the brink of the falls the professor states that the creek has cut down to the Hamilton sandstone, when it descends 75 feet vertically, and then passing out through a narrow channel descends another 50 feet.[1]

No. 1476 B3.—From the ledges along the side of the path below the lower falls. Here the shales are more argillaceous than those along the path by the upper falls, and fossils are more common.

FAUNA OF NO. 1426 B3.

Atrypa reticularis (Linné) Dalm	(rr)
Phacops rana (Green) Hall	(r)
Dalmanites (Cryphæus) boothi (Green) Hall	(rr)
Chonetes lepida Hall	(rr)
Chonetes mucronata Hall	(rr)
Ambocœlia umbonata (Con.) Hall	(rr)
Nucleospira concinna Hall (?)	(rr)
Nuculites oblongatus (Con.) Hall	(rr)
Palæoneilo constricta (Con.) Hall	(rr)
Palæoneilo muta Hall	(rr)
Nucula lirata (Con.) Hall	(rr)
Tellinopsis subemarginata (Con.) Hall	(rr)
Spirifera mucronata (Con.) Bill (?)	(rr)
Pleurotomaria sp	(rr)
Orthoceras sp	(rr)

No. 1476 B4.—A prominent ledge of rocks south of the road, 1½ miles up the falls road from Bushkill, and opposite sign board "one-half mile to Bushkill Falls." The rocks are moderately coarse arenaceous shales. Fossils are not very common, trilobites being the most abundant. It seems rather remarkable that Prof. White, when describing the Hamilton sandstones, should state: "Not a single specimen of a trilobite was observed in all this thickness of rock, at the many localities where

[1] G⁶, p. 212.

it is exposed for observation within the district;"[1] and the statement is repeated by Prof. Lesley in the final report.[2]

It will be seen from the lists of identified fossils reported in this paper, that trilobites are not of uncommon occurrence, but on the contrary appear to be about as abundant as in the Hamilton rocks of central and western New York.

FAUNA OF No. 1476 B4.

Phacops rana (Green) Hall	(aa)
Palæoneilo constricta (Con.) Hall	(r)
Tellinopsis subemarginata (Con.) Hall	(rr)
Pleurotomaria capillaria Con	(rr)
Orthoceras sp	(r)

No. 1476 B5.—Bluish arenaceous shales near the summit of Prickly Pear Hill, west of Bushkill. Only a few specimens of *Nucula corbuliformis* Hall were found.

No. 1476 B6.—At the foot o hill, which is 350 feet lower than B5, a small exposure of bluish-bla de was found in which *Lunulicardium fragile* Hall occurs, but the exposure is not so good as that along the highway at the foot of the hill farther west.

SECTIONS NEAR DINGMANS, PIKE COUNTY, PA.

No. 1476 E1.—Exposures in Hornbecks Creek, at the foot of Indian Ladder Falls, 2½ miles south of Dingmans. The rocks are the blue arenaceous moderately coarse shales of the Hamilton. Fossils are not common. In the bed of the creek are loose blocks of a coarse-grained, somewhat calcareous rock in which fossils are abundant. They are washed down from above and are probably from the calcareous horizon called Tully by Prof. White. Higher up the cliff the fossils are rather more abundant.

FAUNA OF No. 1476 E1.

Spirifera granulifera Hall	(r)
Tropidoleptus carinatus (Con.) Hall	(rr)
Platyceras sp	(rr)
Athyris spiriferoides (Eaton) Hall	(rr)
Spirifera medialis Hall (?)	(r)
Modiomorpha concentrica (Con.) Hall	(rr)
Goniophora hamiltonensis (Hall) Mill	(rr)
Palæoneilo constricta (Con.) Hall	(r)
Nuculites oblongatus Con. (?)	(rr)
Homalonotus de kayi (Green) Emm	(rr)
Paracyclas lirata (Con.) Hall	(rr)
Coleolus tenuicinctum Hall	(rr)
(?) Murchisonia sp	(rr)

[1] G[6], p. 112.

[2] A Summary Desc. of the Geol. of Penn., Vol. II, 1892, p. 1249.

FAUNA OF NO. 1476 E (FROM LOOSE BLOCKS IN HORNBECK CREEK, BELOW INDIAN LADDER FALLS).

Strophomena perplana (Con.) Hall	(rr)
Chonetes coronata (Con.) Hall (?)	(rr)
Tropidoleptus carinatus (Con.) Hall	(rr)
Rhynchonella cf. prolifica Hall	(rr)
Spirifera sp., cf. S. medialis Hall and S. granulifera Hall	(c)

No. 1476 E2.—Farther up the creek, above all the high cascades and where only small ones exist, are blue, somewhat argillaceous shales of irregular cleavage, similar to the finely arenaceous shales of New York, in which fossils are common.

FAUNA OF NO. 1476 E2.

Palæoneilo constricta (Con.) Hall	(a)
Cypricardinia indenta (Con.) Hall	(rr)
Macrodon hamiltoniæ Hall	(rr)
Tellinopsis subemarginata (Con.) Hall	(r)
Orthonota undulata Con	(rr)
Modiomorpha mytiloides (Con.) Hall	(rr)
Nucula corbuliformis Hall	(rr)
Grammysia constricta Hall	(rr)
Spirifera mucronata (Con.) Bill	(rr)
Ambocœlia umbonata (Con.) Hall	(rr)
Phacops rana (Green) Hall	(rr)
Hyolithes aclis Hall	(rr)

No. 1476 H1.—Dingmans, Delaware Township, Pike County, Pa. First rapids in Dingmans Creek, just above the first house and an old mill after turning up the High Falls road, one-half mile from Dingmans. The rock is a bluish, somewhat argillaceous shale, which closely resembles the New York undisturbed layers of similar shale. The dip is not great and the cleavage planes, which in this region generally split the rocks at nearly right angles to the bedding and fossils, are not marked. *Leiorhynchus multicosta* Hall is the most common fossil, but there are species of the smaller lamellibranchs which correlate the exposure with the Hamilton.

FAUNA OF NO. 1476 H1.

Leiorhynchus multicosta Hall	(a)
Nuculites triqueter Con	(rr)
Prothyris sp. (?)	(rr)
Differs from any of the species figured by Prof. Hall.	
Modiella pygmæa (Con.) Hall	(rr)
Nucula lirata (Con.) Hall	(rr)
Actinopteria subdecussata Hall (?)	(rr)
Goniatites sp	(rr)

No. 1476 H2.—The Silver Thread Falls, in a branch that enters Dingmans Creek from the east, have cut down through the thin Hamilton shales along the lines of joints. The line of jointing is 20° north of east and the dip is not great. *Paracyclas lirata* (Con.) Hall and *Rhynchonella* sp. were found at this locality.

No. 1476 H3.—Cliffs along the side and at the top of Deer Leap Falls, of bluish, arenaceous shales, in places approaching a sandstone. Fossils are rather sparingly distributed through the shales, but in certain layers are numerous aviculoid Lamellibranch shells, especially in a layer at the top of the falls. The rock as it splits up is of irregular surface on the under side and above this surface are numerous shells which have the appearance of being somewhat worn, as though they had possibly been washed along the beach for some time. Some of the specimens are in the center of the layers of rock, but more are on the under side, as just described. This locality is mentioned by Prof. White, who says: "Just above [one-fourth mile] the crossing of the old State road is the Deer Lick Falls, where the stream takes a plunge of 40 feet over a cliff of Chemung sandstone whose top is 750 feet A. T."[1]

FAUNA OF NO. 1476 H3.

Paracyclas lirata (Con.) Hall	(rr)
Leda diversa Hall	(rr)
Palæoneilo emarginata (Con.) Hall, variety (?), specimen poorly preserved and identification doubtful	(rr)
Actinopteria boydi (Con.) Hall	(c)
Actinopteria, cf. epsilon Hall	(r)
Palæoneilo plana Hall or P. maxima (Con.) Hall	(rr)
Specimen broken so that it is difficult to decide to which of the above species it belongs.	
Modiomorpha subalata (Con.) Hall, var. chemungensis Hall (?)	(rr)
Grammysia sp.	(rr)

No. 1476 H4.—The cliffs of Fulmer Falls are composed of blue, moderately arenaceous shales, which split up into rather thin layers, in some of which fossils are abundant, a large number of specimens of a few species, principally Lamellibranchs, having been secured.

FAUNA OF NO. 1476 H4.

Paracyclas lirata (Con.) Hall	(aa)
Tropidoleptus carinatus (Con.) Hall	(c)
Leiorhynchus mesacostalis Hall	(aa)
Chonetes lepida Hall	(r)
Chonetes scitula Hall	(r)
Chonetes setigera Hall	(c)
Spirifera mesacostalis Hall	(rr)
Spirifera mesastrialis Hall	(rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall	(rr)
Microdon (Cypricardella) gregarius Hall	(a)
Nucula corbuliformis Hall	(rr)
Hyolithes aclis Hall (?)	(rr)
Palæoneilo filosa (Con.) Hall	(rr)
Leda diversa Hall	(rr)
Nuculites cuneiformis Con	(rr)
Palæoneilo cf. plana Hall	(rr)
But the specimens are larger than those of this species and possibly they are P. maxima (Con.) Hall, although the proportions are not those of typical specimens of this species.	

[1] G[6], p. 207.

Modiomorpha subalata (Con.) Hall var. chemungensis Hall (?) ..... (c)
The specimens are not typical of the above species, but part of them are considerably shorter and resemble the M. quadrula Hall.
Palæoneilo emarginata (Con.) Hall ..... (rr)
Goniophora cf. carinata (Con.) Hall ..... (rr)
Palæoneilo filosa (Con.) Hall ..... (rr)
Actinopteria boydi (Con.) Hall ..... (c)

No. 1476 H5. At about the middle of the upper cascade (Factory Falls) above the old woolen mill, is an irregular, concretionary layer, similar to those seen in Otsego County, N. Y. These concretions lie on the surface near the mill. Above the lower (Fulmer) falls is quite a thick sandstone, which is exposed on the surface in blocks and forms that falls. Prof. White described these falls and the formations as follows: "Just below Fulmerville, the Fulmer Falls of Dingmans Creek occur near the old woolen mill. The stream descends in a cataract from 890 feet A. T. to 850 feet, and then leaps from a narrow platform of sandstone through dark shaly rocks perpendicularly to 800 feet A. T.

"Chemung fossils occur in the dark shales, but none are seen in the more massive bluish-gray sand rocks above; so that this is near the limit of the Chemung; for on above the upper falls 50 feet there is seen the base of a massive grayish-green current-bedded sandstone which is in the Catskill."[1]

FAUNA OF NO. 1476 H5.

Paracyclas lirata (Con.) Hall ..... (rr)
Modiomorpha mytiloides (Con.) Hall ..... (rr)
Nucula corbuliformis Hall (?) ..... (rr)
Prothyris lanceolata Hall ..... (rr)
Phthonia sectifrons (Con.) Hall ..... (rr)
Spirifera mesastrialis Hall ..... (rr)
Chonetes scitula Hall (?) ..... (rr)
Loxonema hamiltoniæ Hall (?) ..... (rr)

No. 1476 H6.—Opposite the old woolen mill in a block of the compact arenaceous shale which has fallen down from the stratum just below the crest of the upper falls, are some fossils, as *Paracyclas lirata* (Con.) Hall, and other species. This stratum is immediately above the concretionary stratum, 1476 H5.

No. 1476 H7.—South of the creek and above the old village is a ledge of grayish coarse-grained sandstone, which at that time was referred to the Catskill[2] by Prof. White, who says: "On above the upper falls 50 feet there is seen the base of a massive grayish-green current-bedded sandstone, which is in the Catskill; it makes a cliff along the hills."[1]

No. 1476 D1.—Exposures of shale along Adams Creek, north of Dingmans and below Mr. Mulford's house. Blue argillaceous shale, in which fossils are common at intervals.

[1] G[6], p. 207.

[2] Prof. White would now correlate this sandstone with the upper Chemung, as was stated on page 12 in reference to the same formation near Sprague ville, Monroe County.

FAUNA OF NO. 1476 D1.

Modiomorpha mytiloides (Con.) Hall	(rr)
(?) Glossites cf. subtenuis Hall	(rr)
Nuculites triqueter (Con.) Hall	(rr)
Tellinopsis subemarginata (Con.) Hall	(rr)
Paracyclas lirata (Con.) Hall	(r)
Orthis vanuxemi Hall	(rr)
Rhynchonella cf. congregata (Con.) Hall	(r)
Chonetes setigera Hall	(rr)
Tropidoleptus carinatus (Con.) Hall	(rr)
One specimen is a young shell.	
Coleolus tenuicinctum Hall	(rr)
Macrodon hamiltoniæ Hall (?)	(rr)
Nucula corbuliformis Hall	(rr)
Modiomorpha cf. small specimens of M. alta (Con.) Hall, possibly young shells of M. mytiloides (Con.) Hall	(rr)
Orthoceras crotalum Hall	(rr)
Actinopteria boydi (Con.) Hall	(c)
(?) Grammysia sp., possibly young of G. constricta Hall	(rr)
Pleurotomaria sp.	(rr)

SECTIONS NEAR MILFORD, PIKE COUNTY, PA.

In the bed of Raymondskill Creek, 3 miles southwest of Milford, above the "Bridal Veil Falls" and below the High Falls, are coarse arenaceous Hamilton shales, some layers of which approach thin sandstones. The rocks have a dip of 16°, 20°, to 25° west of north and a cleavage of 45° to 50° to the southeast. The coral bed, "Tully limestone horizon," is stated to occur at the head of Raymondskill Falls,[1] but it seems to me that it must be farther up the creek, for the coarse, arenaceous shales and thin sandstones continue up the creek some distance above the falls, and in other localities the "coral bed" is near their top. The steep walls of the canyon and the high water did not permit a sufficiently careful examination to determine this point.

After crossing the bridge one-fourth of a mile above the "High Falls," at the summit of the first rise is an exposure of more argillaceous shales, resembling the Genesee shale of Prof. White. The dip is 16°+ about 25° west of north.

At the next small rise in the road, going west, No. 1476 G3, is an outcrop of rather coarse arenaceous shale in which was a beautiful specimen of *Spirophyton velum* (Van.) Hall. This locality is near the Lareaux house and old brewery, and not far east of the Lareaux schoolhouse mentioned by Prof. White.[2]

No. 1476 G1.—On the Chucktown road, about 3 miles from the Delaware River and just west of the house of Mrs. D. M. Case, is a rather prominent ledge of greenish gray coarse-grained sandstone. This is stated by Prof. White to be "the base of the Catskill" (probably

[1] G[6], p. 109.

[2] G[6], p. 202.

Starucca sandstone, which was later called Upper Chemung), "and a few feet below it the bluish-gray fossiliferous shales and sandstones of the Chemung make their appearance."[1]

No. 1476 G2.—The bluish, arenaceous shales below the coarse sandstone contain a moderate fauna, and specimens were collected from small ledges on the low hill north of Mrs. Case's, as well as from a similar hill on the opposite side of the road, southeast of the house. No considerable number of fossils were obtained, but several specimens of a few species such as were usually seen just before the driving out of the fauna by the invasion of the gray sandstones and later red shale. A few good specimens were obtained from some riprap in the road, the exact locality of which was not learned, except that they came from one of the fields in that vicinity.

FAUNA OF NO. 1476 G2.

Orthonota (?) parvula Hall ..... (aa)
Many of the specimens are quite small, as well as those of other species, showing that the conditions were becoming unfavorable for marine life. This species is very abundant on one slab from this locality.
Nuculites oblongatus Con ..... (c)
Palæoneilo emarginata (Con.) Hall ..... (rr)
Nuculites cuneiformis Con ..... (c)
Nucula corbuliformis Hall ..... (aa)
Modiomorpha subalata (Con.) Hall var. chemungensis Hall (?) ..... (rr)
Actinopteria boydi (Con.) Hall ..... (r)
Leptodesma rogersi Hall or L. sociale Hall ..... (rr)
Specimen broken and these two species are apparently closely related.
Rhynchonella sp ..... (rr)
Specimen broken, but apparently of the R. eximia Hall type.
Spirifera sp ..... (rr)

SECTION OF THE SAWKILL CREEK, BETWEEN MILFORD AND DINGMAN TOWNSHIPS, NEAR MILFORD.

No. 1476 F1.—Bridal Veil Cascades in Sawkill Creek below the rustic bridge. The exposures consist of bluish, argillaceous, and coarse arenaceous shales, running into thin sandstones, in which specimens of *Tropidoleptus carniatus* (Con.) Hall are abundant. The dip at the foot of the Bridal Veil, and also on the creek below the bridge, is about 14°.

FAUNA OF NO. 1476 F1.

Tropidoleptus carinatus (Con.) Hall ..... (a)
Palæoneilo emarginata (Con.) Hall (?) ..... (rr)
Nuculites triqueter Con ..... (rr)
Phacops rana (Green) Hall ..... (rr)

No. 1476 F2.—Above the Sawkill Falls and at nearly the last bed rock in the creek are bluish, rather coarse argillaceous shales, which contain many small Lamellibranchs of the Hamilton fauna. On the western side of the creek is a slight excavation, evidently the beginning of a quarry, in which some bluish sandstone appears, with bluish shales below. The locality is about one-fourth of a mile below the pike

[1] G[6], p. 204. In reference to the correlation of the Starucca sandstone see Prosser in Am. Jour. Sci., 3d ser., Vol. XLIV, pp. 218, 219.

bridge, and the sandstone is probably in Prof. White's Chemung, while the shales are from the top of his Genesee. The sandstone is similar to the blue flags of the Hudson River region above Kingston, though not so well developed.

FAUNA OF No. 1476 F2.

Tellinopsis subemarginata (Con.) Hall ..... (a)
Very good and characteristic specimens of this species.
Nuculites oblongatus (Con.) ..... (r)
Palæoncilo constricta (Con.) Hall ..... (c)
Some of the specimens have identically the same form as those from the Cayuga Lake region of New York, so there is not the least doubt in reference to the specific identification.
Palæoncilo muta Hall ..... (rr)
Nuculites triquetcr Con ..... (c)
Leda diversa Hall ..... (rr)
Leda rostellata (Con.) Hall ..... (rr)
Orthonota carinata Con ..... (rr)
Prothyris lanceolata Hall ..... (rr)
Prothyris planulata Hall (?) ..... (rr)
Pholadella radiata (Con.) Hall ..... (rr)
Nucula corbuliformis Hall ..... (a)
Probably the most abundant species of this fauna, and good typical specimens of the species.
Goniophora carinata (Con.) Hall (?) ..... (rr)
Modiella pygmæa (Con.) Hall ..... (rr)
Modiomorpha mytiloides (Con.) Hall ..... (c)
Grammysia lirata Hall (?), ... (r)
Orthonota (?) parvula Hall ..... (rr)
Phacops rana (Green) Hall ..... (c)
Spirifera fimbriata (Con.) Bill ..... (r)
Athyris spiriferoides (Eaton) Hall ..... (rr)
Spirifera granulifera Hall (?) ..... (rr)
Part of a large shell showing granules on the large plications.
Tropidoleptus carinatus (Con.) Hall ..... (rr)
Amboccelia umbonata (Con.) Hall ..... (rr)
Chonetes mucronata Hall ..... (c)
Hyolithes aclis Hall ..... (c)
Coleolus tenuicinctum Hall ..... (rr)
Loxonema delphicola Hall (?) ..... (rr)
Pleurotomaria itys Hall (?) ..... (c)
In the imperfect condition of these specimens it is difficult to distinguish between the above species and P. capillaria Con., but the number and character of the revolving striæ agree more nearly with P. itys Hall.
Bellerophon leda Hall ..... (rr)
Dalmanites (Cryphæus) boothi (Green) Hall, possibly the variety calliteles Green ..... (rr)
Cyclonema hamiltoniæ Hall (?) ..... (rr)
Bellerophon brevilineatus Con. (?) ..... (rr)
(?) Sphenotus cf. cuneatus (Con.) Hall ..... (rr)
(?) Leiopteria or Leptodesma, not well enough preserved in order to decide which genus.
Orthoceras sp ..... (r)
Crinoid stems, small.
Spirophyton sp.
Fragments of fossil plants.

The outcrop from which the above list of fossils was obtained is one of the typical exposures of the zone which was referred by Prof. White to the Genesee shale. The upper part of this gorge of the Sawkill which "rapidly excavates a long narrow cañyon out of the Genesee shale,"[1] is one of the best localities in the zone for collecting fossils. A table showing the geologic range of most of the species in the above list has been prepared, and this shows that only one species of the above list, *Ambocœlia umbonata* (Con.) Hall, has been reported from the Genesee shale of New York, while, with one exception, every species is credited to the Hamilton.

Fauna of No. 1476 F?, with table of geologic range.

Number of species.	List of species.	Abundance.	Geologic stage. *									
			Oriskany.	Schoharie grit.	Upper Helderberg.	Marcellus shale.	Hamilton.	Tully limestone.	Genesee shale.	Portage.	Ithaca.	Chemung.
1	Nucula corbuliformis Hall	a					×				?	
2	Tellinopsis subemarginata (Con.) Hall	a					×					
3	Palæoneilo constricta (Con.) Hall	c					×			×	×	
4	Nuculites triqueter Con	c				?	×					
5	Modiomorpha mytiloides (Con.) Hall	c					×					
6	Phacops rana (Green) Hall	c			?	×	×	×				×
7	Chonetes mucronata Hall	c			×	×	×					
8	Hyolithes aclis Hall	c					×			×		
9	Pleurotomaria itys Hall	c					×					
10	Nuculites oblongatus Con	r					×			×		
11	Spirifera fimbriata (Con.) Bill	r	×	×	×		×	×			×	×
12	Palæoneilo muta Hall	rr					×					
13	Leda diversa Hall	rr					×					
14	Leda rostellata (Con) Hall	rr					×			×		
15	Orthonota carinata Con	rr					×					
16	Prothyris lanceolata Hall	rr					×			×		
17	Pholadella radiata (Con.) Hall	rr					×				×	
18	Goniophora carinata (Con.) Hall (?)	rr								×		
19	Modiella pygmæa (Con.) Hall	rr					×					
20	Orthonota (?) parvula Hall	rr					×					
21	Athyris spiriferoides (Eaton) Hall	rr			×		×					
22	Tropidoleptus carinatus (Con.) Hall	rr					×			×		×
23	Ambocœlia umbonata (Con.) Hall	rr				×	×	×	×		×	?
24	Coleolus tenuicinctum Hall	rr					×					
25	Loxonema delphicola Hall (?)	rr					×					
26	Bellerophon leda Hall	rr					×					
27	Dalmanites (Cryphæus) boothi (Green) Hall; possibly the var. calliteles Green	rr			×	×	×	×				
28	Orthoceras sp. fragments	rr										
29	Spirifera granulifera Hall (?)	rr					×					
30	Grammysia lirata Hall (?)	rr					×					
31	Cyclonema hamiltoniæ Hall (?)	rr					×					
32	Bellerophon brevilineatus Con. (?)	rr					×					

* The data used in showing the geologic range of the species in the above list are derived principally from the various works of Professors Hall, H. S. Williams, and Clarke, and the distribution is confined mainly to New York. The reported occurrence of certain species farther south along the line of the Appalachians is intentionally left out of consideration, until further investigation shall enable us to compare their stratigraphic position and faunas more carefully with the New York series. Consequently the range of each species is based upon references concerning the reliability of which there is believed to be no question, or upon data that are personally known to be accurate. This is a principle that is frequently ignored in the preparation of large tables of distribution and range of species.

[1] Prof. White, G[6], p. 199.

No. 1476 F3.—Cliff of bluish argillaceous shale on east bank of creek above the Sawkill Falls. The shales split up into thin pieces are fine-grained and like those of the characteristic Hamilton. The fossils are common, mostly small Lamellibranchs, and in the horizon of Prof. White's Genesee shale.

FAUNA OF NO. 1476 F3.

Palæoneilo constricta (Con.) Hall	(rr)
Modiella pygmæa (Con.) Hall	(rr)
Nuculites oblongatus Con	(rr)
Tellinopsis subemarginata (Con.) Hall	(c)
Nucula lirata (Con.) Hall (?)	(rr)
A small and probably young shell.	
Grammysia sp	(rr)
Ambocœlia umbonata (Con.) Hall	(r)
(?) Psilophyton princeps Dn	(rr)
Spirifera mucronata (Con.) Bill	(rr)
Chonetes mucronata Hall	(rr)
Chonetes setigera Hall	(rr)
Loxonema hamiltoniæ Hall (?)	(rr)
Dalmanites (Cryphæus) boothi (Green) Hall	(rr)
Pleurotomaria sp	(rr)
Cf. Eugaster logani Hall	(rr)

No. 1476 F4.—Exposures in the creek, under the cliff of F3, and above the cascade which is a little higher than the brink of Sawkill Falls. These shales are rather coarser and somewhat more arenaceous than those a little higher up the bluff, but fossils are still common.

Along the eastern side of the canyon, 15 to 20 feet and higher above the cascade, at the top of the Sawkill Falls, are mainly argillaceous shales in association with some that are slightly arenaceous. Fossils are common, especially small Lamellibranchs, near the base of the "Genesee shale" zone.

FAUNA OF NO. 1476 F4.

Palæoneilo constricta (Con) Hall	(a)
Palæoneilo plana Hall (?)	(rr)
Palæoneilo muta Hall	(rr)
Nuculites oblongatus Con	(rr)
Tellinopsis subemarginata (Con.) Hall	(rr)
Chonetes coronata (Con.) Hall	(c)
Ambocœlia umbonata (Con.) Hall	(a)
Spirifera mucronata (Con.) Bill	(rr)
Macrodon hamiltoniæ Hall	(rr)
Modiella pygmæa (Con.) Hall	(rr)
Nucula corbuliformis Hall	(rr)
Nucula bellistriata (Con.) Hall	(rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall	(rr)
Modiomorpha concentrica (Con.) Hall	(rr)
Two of the specimens are young shells like fig. 2, Pl. XXXV, (Geol. Surv. N. Y., Palæontology, Vol. V, Pt. I, Lamellibranchiata II.)	
Orthonota (?) parvula Hall	(rr)

Paracyclas tenuis Hall (?) or possibly the young of P. lirata (Con.) Hall..... (rr)
Coleolus tenuicinctum Hall ..... (rr)
Hyolithes aclis Hall (?)..... (rr)
Loxonema delphicola Hall..... (r)
Pleurotomaria lucina Hall (?)..... (rr)
Phacops rana (Green) Hall..... (r)
Homalonotus dekayi (Green) Em..... (rr)
Dalmanites (Cryphæus) boothi (Green) Hall..... (rr)
Chonetes setigera Hall..... (r)
Actinopteria decussata Hall..... (rr)
Cf. Pterinopecten vertumnus Hall..... (rr)
Bellerophon sp..... (rr)

No. 1476 F5.—On the brink of the cascade, just above Sawkill Falls, are blue, rather coarse shales, with fossils abundant in layers, but elsewhere they are rare. Lamellibranch and Brachiopod shells, with Bryozoa, are present; but neither corals nor a stratum similar to the coral bed in Saw Creek near Bushkill, and other localities, was seen. I am not sure that the cascade is exactly the horizon for this zone in the creek, but it is near the beginning of the rather coarse arenaceous Hamilton shales, which are well shown farther down the creek. The zone above called Genesee is the blue argillaceous shale of the Hamilton, and a good collection of the characteristic smaller Lamellibranchs of this zone of the Hamilton was secured.

FAUNA OF NO. 1476 F5.

Palæoneilo constricta (Con.) Hall..... (rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall..... (rr)

No. 1476 F6.—At about the middle of the cascade above Sawkill Falls, is a layer containing a mass of shells in which Crinoid stems are present while *Spirifers* as well as several other species are abundant. This may possibly represent the coral stratum. The rock is heavier and more arenaceous than that above the cascades. Beginning in the nearly vertical part of the Sawkill Falls, the rocks change to the coarse, arenaceous Hamilton shales, which are at their base in the bed of the creek.

FAUNA OF NO. 1476 F6.

Spirifera mucronata (Con.) Bill..... (a)
Spirifera granulifera Hall..... (a)
Spirifera medialis Hall..... (a)
These two species are abundant, but the condition of casts in which they occur renders it difficult to discriminate specifically between many of the specimens. A few external impressions show very clearly the presence of granules, and other specimens have the characteristic form of S. medialis.
Orthis vanuxemi Hall..... (c)
Atrypa reticularis (Linné) Dalm..... (rr)
Tropidoleptus carinatus (Con.) Hall..... (r)
Orthonota undulata Con..... (rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall..... (rr)

Loxonema hamiltoniæ Hall..... (rr)
Strophodonta sp..... (rr)
Discina sp..... (rr)
Orthoceras sp..... (rr)
Bryozoa.....

Prof. White described the upper portion of the Sawkill Canyon as follows: "Beginning one-quarter of a mile up the stream from the main falls, we find the Sawkill flowing between banks of drift, which it here cuts through, and rapidly excavates a long narrow canyon out of the Genesee shale. This trench is 110 feet deep where the falls begin, only about 50 feet wide at top, and 10 to 15 feet at the bottom. The first descent is a fall of 20 feet in two cascades over the fossil coral bed at the base of the Genesee; then the stream spreads out on a broad gently sloping platform of gray Hamilton rock, to fall into the great abyss below in a vertical plunge of 60 feet. * * * The fossil coral bed at the top of the large fall is a dark blue slaty rock filled with corals, and also many fossil shells."[1]

SECTIONS NEAR PORT JERVIS, N. Y.

No. 1477 A—1.—At the northern end of the city near the base of the steep hill is an exposure of bluish-black fine shales, which are probably Marcellus, and above, up the steep hillside, are ledges of coarse, arenaceous shale, which are of Hamilton age. The exposure is at a point where riprap has been taken out extensively for the streets of the city.

No. 1477 A1.—The ledges forming the high hill immediately north of Port Jervis are composed of coarse arenaceous shales and sandstones, which belong to the lower part of the Hamilton stage.

FAUNA OF NO. 1477 A1.

Tropidoleptus carinatus (Con.) Hall..... (rr)
Spirifera medialis Hall..... (rr)
Spirifera mucronata (Con.) Bill..... (rr)
Cyrtina hamiltonensis Hall..... (rr)
Bryozoa.

No. 1477 A2.—A ledge of coarse-grained sandstone with coarse arenaceous shales, on eastern side of the road, 1½ miles north of Port Jervis. This is the first ledge after passing those so well exposed in, and extending a mile north of, Port Jervis. Some of the layers of this ledge contain great numbers of shells, principally *Spirifera granulifera* Hall.

FAUNA OF NO. 1477 A2.

Spirifera granulifera Hall..... (aa)
A large number of specimens in a coarse-grained sandstone, which is very much indurated, and most of the specimens are internal or external impressions on which the finer markings are not preserved. Some of the specimens may be S. medialis Hall, but owing to the condition of preservation it is hardly possible to identify them.

[1] G[6], p. 199.

Nucula corbuliformis Hall	(a)
Nuculites cuneiformis Con. (?)	(rr)
Chonetes coronata (Con.) Hall	(c)
Tropidoleptus carinata (Con.) Hall	(rr)
Pterinea flabellata (Con.) Hall	(rr)
Modiomorpha concentrica (Con.) Hall (?)	(rr)
Modiomorpha cf. subalata (Con.) Hall	(rr)
Leda rostellata (Con.) Hall	(rr)
Ambocœlia umbonata (Con.) Hall	(r)
Leiorhynchus multicosta Hall	(rr)
Spirifera mucronata (Con.) Bill	(c)
(?) Terebratula sp	(r)

No. 1477 A3.—A short distance farther up the road are coarse, quite fossiliferous, arenaceous shales, forming ledges on the hillside above the highway. Above these, farther up the hillside, the shales become more argillaceous, split up into finer pieces, and contain the smaller Lamellibranchs. This zone is apparently near the horizon called Genesee by Prof. White, and the transition is not far south of a private bridge across the Delaware and Hudson Canal.

FAUNA OF NO. 1477 A3.

Tropidoleptus carinatus (Con.) Hall	(aa)
Orthis vanuxemi Hall	(a)
Modiomorpha concentrica (Con.) Hall	(rr)
Microdon (Cypricardella) bellistriatus (Con.) Hall	(rr)
Palæoneilo constricta (Con.) Hall	(rr)
Nucula corbuliformis Hall	(r)
Nuculites oblongatus Con	(r)
Tellinopsis subemarginata (Con.) Hall	(r)
Pholadella radiata (Con.) Hall (?)	(rr)
Grammysia constricta Hall	(rr)
Orthonota (?) parvula Hall	(rr)
Orthonota undulata Con	(rr)
Paracyclas lirata (Con.) Hall	(rr)
Grammysia arcuata (Con.) Hall (?)	(rr)
Modiella pygmæa (Con.) Hall	(rr)
Homalonotus dekayi (Green) Em	(rr)
Loxonema hamiltoniæ Hall	(rr)
Bellerophon leda Hall	(rr)
Spirifera mucronata (Con.) Bill	(c)
(?) Cryptonella planirostra Hall	(rr)
Glyptodesma erectum (Con.) Hall	(rr)
Cyrtina hamiltonensis Hall	(rr)
Colcolus tenuicinctum Hall	(rr)

DELAWARE RIVER SECTION.

No. 1477 A8.—A ledge of rock on the eastern side of the highway, forming quite a steep hill, one-fourth of a mile south of Sparrowbush. Rather coarse arenaceous shales, containing numerous fossils in certain layers. This outcrop as mapped by Prof. White is probably near the top of the Hamilton, the Genesee zone forming the next covered slope

to the north. Possibly the covered slope to the south is his Genesee, in which case this exposure would be the base of the Chemung according to his correlation.

Prof. White states: "It [the Genesee] is well exposed along the Delaware river on the New York shore, 2 miles above Port Jervis, where it is seen dipping north 25°, west 10° to 11°, and exhibiting clearage planes at a high angle to the southeast. It is also quite fossiliferous, containing *Spirifer mucronatus*, *Athyris spiriferoides*, *Microdon bellistriata*, *Tropidoleptus carinatus*, and many other forms."[1] Prof. Lesley says the Genesee makes its appearance "at the ninetieth milepost of the Erie Railroad" and describes it as composed of "dark sandy slates, 200 feet thick, holding *Spirifera mucronata*, *Athyris spiriferoides*, *Tropidoleptus carinatus*. (?)"[2] It seemed odd to the writer when he first saw the statement that these rocks were called Genesee, because the fossils enumerated have never been regarded as characteristic Genesee species in New York. This will be immediately appreciated on noting the range of the species mentioned: *Spirifera mucronata* (Con.) Bill. occurs in the Marcellus, Hamilton, and doubtfully in the Portage of eastern New York; *Athyris spiriferoides* (Eaton) Hall, in the Upper Helderberg and Hamilton; *Microdon bellistriatus* (Con.) Hall, in the Hamilton, Ithaca, Portage of eastern Pennsylvania, and Chemung; *Tropidoleptus carinatus* (Con.) Hall, in the Hamilton, Portage, Portage of eastern New York and Pennsylvania, Oneonta, and Chemung.

FAUNA OF NO. 1477 A8.

Tropidoleptus carinatus (Con.) Hall	(aa)
Spirifera mucronata (Con.) Bill	(aa)
Spirifera tullia Hall (?)	(rr)
Palæoneilo constricta (Con.) Hall	(r)
Nuculites triqueter Con	(rr)
Palæoneilo emarginata (Con.) Hall	(rr)
Nucula bellistriata (Con.) Hall	(rr)
Palæoneilo muta Hall	(rr)
Palæoneilo maxima (Con.) Hall	(rr)
Nucula corbuliformis Hall	(r)
Nuculites oblongatus Con	(c)
Nuculites cuneiformis Con	(rr)
Goniophora hamiltonensis (Hall) Mill	(rr)
Microdon (Cypricardella) tenuistriatus Hall (?)	(c)
Tellinopsis subemarginata (Con.) Hall	(rr)
Pholadella radiata (Con.) Hall	(rr)
Leda diversa Hall	(rr)
Grammysia bisulcata (Con.) Hall	(rr)
Cimitaria corrugata (Con.) Hall	(rr)
Hyolithes aclis Hall	(rr)
Tentaculites bellulus Hall	(c)
Actinopteria boydi (Con.) Hall	(rr)
Cyrtina hamiltonensis Hall	(rr)

[1] G[6], p. 108.

[2] Sum. Desc. Geol. Penn., Vol. II, p. 1247, footnote; see in addition p. 1325.

Chonetes setigera Hall	(a)
Chonetes scitula Hall	(c)
Nucleospira concinna Hall	(rr)
Spirifera granulifera Hall	(rr)
Athyris spiriferoides (Eaton) Hall	(rr)
Leiorhynchus multicosta Hall	(rr)
Coleolus tenuicinctum Hall	(rr)
Psilophyton princeps Dn	(rr)
Pleurotomaria capillaria Con. (?)	(r)
Bellerophon acutilirata Hall	(rr)
Lingula sp	(rr)
Trilobite, fragment of glabella	(rr)
Spirophyton sp	(rr)

No. 1477 A7.—Exposures on the Pennsylvania side of the Delaware River, a little above Sparrowbush and opposite the ninetieth New York mile-post on the Erie Railroad. These are coarse arenaceous blue shales and sandstones, some layers being of concretionary structure. Dip about 8°, 25° west of north. Fossils not common, but in a rather blocky shale several Hamilton species were found.

FAUNA OF NO. 1477 A7.

Orthis vanuxemi Hall (?)	(rr)
Spirifera mucronata (Con.) Bill	(c)
Leiorhynchus sp	(a)
The specimens have the form of L. multicosta Hall, but are without plications on the sides, and in this respect agree with L. mesacostalis Hall.	
Glyptodesma erectum (Con.) Hall (?)	(rr)
Palæoneilo emarginata (Con.) Hall	(rr)
Paracyclas lirata (Con.) Hall	(r)
Pholadella radiata (Con.)	(rr)
Nuculites corbuliformis Hall	(c)
Leda diversa Hall (?)	(rr)
Cyrtolites (Crytonella) pileolus Hall	(rr)
Productella sp	(rr)
Dalmanites (Cryphæus) boothi (Green) Hall (?)	(rr)

No. 1477 A4.—On the western bank of the Delaware River, just below the New York, Lake Erie and Western Railroad bridge, are shales and sandstones which belong in the Chemung of Prof. White. The course of the river at this point is nearly from north to south, and not far below the bridge the dip on the edges of the layers is from 5° to 10° nearly due north. A little farther south the dip is only slightly to the north, while still farther south, where the river strikes the almost vertical cliff, the dip is greater toward the north. It is probable that this dip on the face of the layers to the north does not represent the greatest dip of the rocks at this locality. Some of the joints in the rock enter the river at about 32° east of north. The exposure consists of thin, blue sandstones, alternating with bluish, rather arenaceous shales. There are concretionary layers at irregular intervals and some layers of sandstone with an undulating or warped structure. Fossils are comparatively rare in the shales, and still more so in the sandstones. The blue sandstone is quite similar to the blue quarry stone along the

Hudson river in Ulster and Green counties, called commercially the "North River stone." The ninty-first milepost is in the first railroad cut a short distance north of the railroad bridge, at which locality is a fine exposure of the irregular concretionary structure, some of the concretions being very large. Prof. White stated: "The Chemung rocks rise from the Delaware about 300 yards above the ninety-second New York milepost on the Erie Railroad. This is about one-half mile above the Erie Railroad bridge and $4\frac{1}{6}$ miles from Port Jervis."[1] It is quite clear that the ninety-first milepost is meant, since the distance from the railroad bridge shows that it is not the ninety-second one.

FAUNA OF NO. 1477 A4.

Spirifera mesastrialis Hall ..... (rr)
Palæoneilo emarginata (Con.) Hall ..... (rr)
Leda diversa Hall ..... (r)
Microdon (Cypricardella) tenuistriatus Hall (?), possibly M. gregarius Hall, but it resembles the former more closely ..... (rr)
Orthonota carinata Con ..... (rr)
Palæoneilo plana Hall ..... (rr)
Paracyclas lirata (Con.) Hall ..... (rr)
Grammysia subarcuata Hall (?) ..... (rr)
Modiomorpha mytiloides (Con.) Hall (?) ..... (rr)
Small specimen which closely resembles the young forms of this species as given in figs. 2 and 3 on Pl. XXXVIII (Geol. Surv. N. Y., Palæontology, Vol. V, Pt. I, Lamellibranchiata II).
Modiomorpha subalata (Con.) Hall var. chemungensis Hall(?) ..... (rr)
Leiorhynchus sp., specimens intermediate between L. multicosta Hall and L. mesacostalis Hall ..... (rr)
Actinopteria boydi (Con.) Hall ..... (a)
(?) Psilophyton princeps Dn., broken fragments of plant stems ..... (r)
(?) Crania sp., or possibly Discina sp ..... (rr)

No. 1477 A5.—Exposures of bluish sandstone and shales on the western bank of river about opposite the Saw Mill Rift siding of the Erie Railroad, and a little more than 900 feet above the ninety-first milepost. (This is probably near the horizon of the place indicated by Prof. White as the top of the Chemung, since on the opposite side of the river, a short distance above this point, heavy sandstone ledges begin to appear which are probably Starucca.) The upper exposures at this locality are thin greenish-gray sandstones, alternating with blue argillaceous shales. A little farther down, one of the heavy irregular layers is near the level of the river, and the sandstones of this exposure are blue and fine grained. The blue shales contain fragments of some fossils, as *Homalonotus dekayi* (Green) Emm.

FAUNA OF NO. 1477 A5.

Homalonotus DeKayi (Green) Emm ..... (rr)
Palæonelio emarginata (Con.) Hall var. (?) ..... (rr)
(?) Psilophyton princeps Dn ..... (rr)
Aviculoid shell ..... (rr)
Gasteropod shell ..... (rr)

[1] G[6], p. 194.

No. 1477 A6.—Exposures along the high bluff on the east side of the Delaware River, near the point on the highway called the Hawks Nest, 4 miles above Port Jervis. This locality is farther up the river than Saw Mill Rift on the opposite side. There are coarse grayish sandstones, with argillaceous blue to olive shale partings. Near the narrowest part of the road is a layer of blue argillaceous shale, just above a sandstone stratum, that contains *Archæopteris sphenophyllifolia* Lx., of which several good specimens were obtained that agree well with Lesquereux's description.[1] Through the kindness of Mr. Lacoe these specimens have been compared with the type specimen and figure, one frond of which is fully as well preserved as the type specimen from Meshoppen, Pa. This species has been reported from the lower Catskill of Meshoppen, Wyoming County, Pa. Fronds of *Haliserites* occur, similar to *H. Dechenianus* Göpp, var. *lineatus* Pn.,[2] which is found at Lanesboro, Pa., and a few other localities near this geologic horizon.

The dip along a north and south line is between 10° and 12° to the north.

No. 1477 B1.—In the Erie Railroad cut, just west of Pond Eddy, is a prominent layer of cornstone 4 to 5 feet in thickness, in the midst of the Delaware flags, which are massive greenish-gray sandstones. Dip along an east and west line varies from 1° to 5° in the different layers.

No. 1477 B2.—The New Milford red shale, just below Pond Eddy station, is not much over 15 feet in thickness. It is exposed for about 100 feet, with an average dip of 8°, and 50 feet farther with a dip of about 4°, making a thickness of 17 feet for the shale.

No. 1477 B3.—This station is a quarry, a short distance below Stairway, and opposite the ninety-sixth New York milepost on the Erie Railroad. On a smooth bedplane there is a dip of 9° between 25° and 30° west of north; on the side of the quarry the dip is hardly so great. Near the top of the quarry, in an argillaceous, olive, shaly stratum, are specimens of *Psilophyton princeps* Dn., which are not very abundant. At Barryville, Sullivan County, N. Y., in a quarry one-half mile up Halfway Brook, is a bluish-gray sandstone quarried for flagging. The dip is apparently about 40° west of north, while in an old quarry on the southside of the brook, nearer the village, the dip is 6° between 30° and 40° east of north. There are extensive flagstone quarries near Shohola.

Along the New York, Lake Erie and Western Railroad, from Shohola, Pa. (opposite Barryville), to Lackawaxen, the rocks consist of greenish-gray sandstone, with partings of olive and red shales. No fossils were seen in these rocks, except plant stems, which show no fronds. Near the northern end of the first railroad cut, west of the one hundred and eleventh New York milepost and Lackawaxen, in a mealy shale, were found a few poorly preserved pinnules of *Archæopteris*, with numerous fern stems; and in association with these, in the greenish argillaceous shales, specimens of *Haliserites*.

[1] 2d Geol. Survey, Penna., p. 3, Coal Flora, Vol. III, p. 775.
[2] Proc. Nat. Mus., Vol. XVI, p. 109, Pl. X, fig. 7.

In a quarry south of Narrowsburg, N. Y., and one-half mile up the hillside, is a good exposure of the greenish-gray, coarse-grained flagstone. A dip of 4° to 5°, 20° to 30° west of south, is shown in the quarry. In an old quarry three-fourths of a mile south of Narrowsburg, and in ledges along the western slope of the hill, are numerous exposures of the greenish-gray sandstone, with argillaceous shale partings. Some of the finer of these shales contain fragments of *Archæopteris*. At several places along the ledges are good examples of current bedding. The dip on the floor of the quarry is about 5° between 30° and 40° east of north. An outcrop of red shale occurs a few rods north of the quarry.

The section along the line of the Delaware River was not examined west of Narrowsburg, and, with the exception of plants, no fossils were found above Saw Mill Rift. The zone above Henryville, on the Delaware, Lackawanna and Western Railroad, was not detected along the Delaware River.

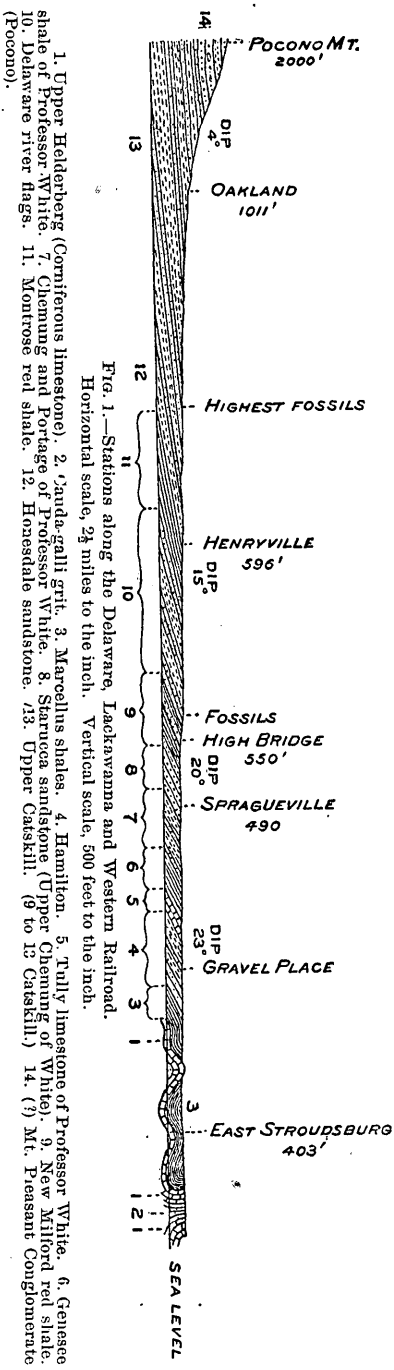

FIG. 1.—Stations along the Delaware, Lackawanna and Western Railroad. Horizontal scale, 2½ miles to the inch. Vertical scale, 500 feet to the inch.

1. Upper Helderberg (Corniferous limestone). 2. Oriskany grit. 3. Marcellus shales. 4. Hamilton. 5. Tully limestone of Professor White. 6. Genesee shale of Professor White. 7. Chemung and Portage of Professor White. 8. Staurocа sandstone (Upper Chemung of White). 9. New Milford red shale. 10. Delaware river flags. 11. Montrose red shale. 12. Honesdale sandstone. 13. Upper Catskill. (9 to 12 Catskill.) 14. (?) Mt. Pleasant Conglomerate (Pocono).

NEVERSINK RIVER SECTION.

After making the section along the Delaware River, the strike of the Middle and Upper Devonian was followed northeast from Port Jervis, through Orange, Sullivan, Ulster, and Greene counties, N. Y.

No. 1478 A1.—At Rose Point, on the Monticello and Port Jervis Railroad, 8 miles northeast of Port Jervis, is a good exposure of arenaceous shales and sandstones by the railroad, at the base of the hill. In the gravel quarry at the southern end are thin, black, argillaceous shales alternating with thin sandstones. The base of some of the sandstone layers is pebbly. This horizon is apparently near the dividing line of the Marcellus and Hamilton. A little farther north, on the western side of the railroad, is an excellent exposure of

coarse blue arenaceous shales, with sandstones 1 foot or more in thickness, belonging to the Hamilton stage.[1] Fossil shells are abundant, and in some of the shale a few fossil plants were found. The dip is 45°, about 30° west of north.

FAUNA OF NO. 1478 A1.

Spirifera granulifera Hall	(c)
Spirifera medialis Hall (?)	(rr)
Spirifera mucronata (Con.) Bill	(rr)
Tropidoleptus carinatus (Con.) Hall	(rr)
Nyassa arguta Hall	(c)
Nucula varicosa Hall	(rr)
Modiomorpha concentrica (Con.) Hall	(rr)
Chonetes mucronata Hall	(r)
Rhynchonella congregata (Con.) Hall	(r)
Athyris spiriferoides (Eaton) Hall	(r)
Chonetes deflecta Hall (?)	(rr)
Ambocœlia umbonata (Con.) Hall	(c)
Palæoneilo emarginata (Con.) Hall	(r)
Nucula corbuliformis Hall	(r)
Nuculites triqueter Con	(rr)
Palæoneilo constricta (Con.) Hall	(rr)
Palæoneilo plana Hall (?)	(rr)
Nyassa recta Hall (?)	(rr)
Modiomorpha subalata (Con.) Hall (?)	(c)
Macrodon hamiltoniæ Hall	(rr)
Grammysia bisulcata (Con.) Hall	(rr)
Homalonotus dekayi (Green) Emm	(r)
Dalmanites (Cryphæus) boothi (Green) Hall (?)	(rr)
Pleurotomaria sulcomarginata Con. or P. itys Hall	(c)
The specimens are internal impressions, some of which resemble one species closer and the remainder the other species.	
Bellerophon patulus Hall (?), possibly B. natator Hall	(rr)
Loxonema delphicola Hall	(rr)
Orthoceras crotalum Hall	(rr)
Conularia undulata Con	(rr)
Lepidodendron gaspianum Dn., with elliptical areoles which contain central leaf scars as described by Dawson	(rr)
(?) Psilophyton princeps Dn	(rr)
Pterinea flabellata (Con.) Hall	(rr)
Actinopteria boydi (Con.) Hall	(r)
Actinopteria decussata Hall (?)	(rr)
Streptorhynchus chemungensis (Con.) Hall	(rr)
Platyceras sp	(rr)

Two specimens of Pectinidæ.

No. 1478 A2.—Nearly 1 mile up the highway from Rose Point and 200 feet higher, just below Mr. M'Carron's house, are ledges of thin flaggy stone which split into layers between one-half and 1 inch in thickness. The stone is very arenaceous, of slightly greenish tint, and may be called a sandstone with very thin layers. Fossils are common, especially *Tropidoleptus carinatus* (Con.) Hall and *Spirifera mucronata* (Con.) Bill.(?). The rocks of this exposure, both in lithologic and

[1] In MacFarlane's Am. Geolog. Railway Guide, 2d ed., p. 126, the age of the rocks at Rose Point is given as Chemung.

paleontologic character, resemble closely the horizon in Pennsylvania and along the Delaware River, called Chemung by Prof. White, and by the writer are regarded as the continuation of that zone.

FAUNA OF NO. 1478 A2.

Spirifera mucronata (Con.) Bill. (?) ..... (aa)
Possibly these specimens ought to be called S. mesacostalis Hall, but they seem to belong to the former. A few specimens show a fold in the bottom of the sinus, and it is difficult to separate them from the form of S. mesacostalis given as fig. 5 on pl. 40 (Geol. Surv., N. Y., Palæontology, Vol. IV, Pt. I), also see variety of S. mucronata figured by Prof. H. S. Williams on pl. 12, fig. 13, Bull. Geol. Soc. Am., Vol. I.
Tropidoleptus carinatus (Con.) Hall ..... (a)
Palæoneilo constricta (Con.) Hall ..... (rr)
Cyrtina hamiltonensis Hall ..... (rr)
Microdon (Cypricardella) gregarius Hall ..... (c)
Paracyclas lirata (Con.) Hall ..... (rr)
Modiomorpha subalata (Con.) Hall (?) ..... (rr)
Actinopteria boydi (Con.) Hall (?) ..... (rr)
Chonetes mucronata Hall (?) ..... (rr)
Chonetes setigera Hall ..... (rr)

No. 1478 A3.—This exposure is the Meyers quarry near the top of the hill, north of the highway, and about 430 feet higher than A2, or 630 feet above the railroad level at Rose Point. The rock is mainly a bluish-gray flagstone separated by partings of shale, and the sandstone is quarried for flagging. An occasional stratum of sandstone shows a slight reddish tint, while in some of the shale are masses of fern stipes without pinnules, and possibly some of *Psilophyton*. Somewhat lower, on the hillside, is a ledge which has a dip of 13° between 10° and 20° west of north, and a northeast and southwest strike.

No. 1478 B1.—Just northwest of Cuddebackville, a station on the Summitville Division of the New York, Ontario and Western Railroad, 1 mile northeast of Rose Point, is a low hill, at the base of which are black, argillaceous shales with some arenaceous layers. The Summitville level of the Delaware and Hudson Canal is 610 feet A. T., which level extends from near Rose Point to Summitville, and these shales are about 45 feet higher, or with an approximate altitude of 655 feet. A little higher than the lower exposures, along a wood road, are abundant Hamilton fossils, especially *Tellinopsis subemarginata* (Con.) Hall, in association with the species which are usually common in the black, argillaceous Hamilton shales. It is reasonably sure, from the stratigraphic position, lithologic character, and the fauna, that this zone is the continuation of the horizon considered by Prof. White as "Genesee" in Pennsylvania.

FIG. 1.—Stations along the Delaware, Lackawanna, and Western Railroad.

FAUNA OF NO. 1478 B1.

Paracyclas lirata (Con.) Hall ..... (a)
Nuculites oblongatus Con ..... (rr)
Nucula bellistriata (Con.) Hall ..... (rr)
Tellinopsis subemarginata (Con.) Hall ..... (c)

Modiella pygmæa (Con.) Hall ..... (r)
Leda rostellata (Con.) Hall ..... (rr)
Nucula corbuliformis Hall ..... (r)
Nuculites triqueter Con ..... (rr)
Modiomorpha mytiloides (Con.) Hall ..... (c)
Modiomorpha subalata (Con.) Hall (?) ..... (rr)
Macrodon hamiltoniæ Hall ..... (rr)
Lunulicardium fragile Hall ..... (rr)
Spirifera fimbriata (Con.) Hall ..... (r)
Ambocœlia umbonata (Con.) Hall ..... (a)
Chonetes setigera Hall ..... (r)
Chonetes mucronata Hall (?) ..... (rr)
Chonetes scitula Hall (?) ..... (rr)
Spirifera mucronata (Con.) Bill ..... (r)
Nucula Randalli Hall (?) ..... (rr)
The specimen is longer than any of the forms figured by Prof. Hall.
Dalmanites (Cryphæus) Boothi (Green) Hall ..... (rr)
Phacops rana (Green) Hall ..... (rr)
Pleurotomaria sulcomarginata Con. (?) ..... (r)
Bellerophon crenistria Hall (?) ..... (rr)
Orthoceras crotalum Hall ..... (rr)
Grammysia sp ..... (rr)
Bellerophon sp ..... (rr)
(?) Leiopteria sp ..... (rr)
(?) Pterinopecten sp ..... (rr)
Crinoid stems.

No. 1478 B2.—On the hill about 1 mile west of Port Orange, in Deer Park school district No. 11, near the county line, is the Weingardner quarry. Port Orange station is 1 mile above the Cuddebackville station, and the quarry is about 410 feet above the canal, or with an approximate elevation of 1,020 feet A. T. The dip in this quarry is heavy, varying from 24° to 28°, and the direction is apparently between 20° and 30° north of west. Near the bottom of the quarry, the dip is irregular; while farther north, along the ridge, is an old quarry in which the workmen report a greater dip. The stone is the bluish Hamilton sandstone which splits into flags 1 to 2 inches in thickness, with shaly sandstones and shales forming partings. In the strata, near the bottom of the quarry, are a good many fossil shells of large Lamellibranchs, as *Glyptodesma* and *Grammysia*, while specimens of *Lepidodendron*, called "fossil snakes" by the quarrymen, were also found.

Shells are not common in the upper layers of the quarry. The workmen showed me crystals of quartz, galena, zinc, and iron pyrites from a small vein in the quarry.

FAUNA OF NO. 1478 B2.

Glyptodesma erectum (Con.) Hall ..... (aa)
Actinopteria boydi (Con.) Hall (?) ..... (r)
Spirifera granulifera Hall ..... (rr)
Homalonotus dekayi (Green) Emm ..... (rr)
Grammysia magna Hall ..... (rr)
Grammysia bisulcata (Con.) Hall ..... (rr)
Sphenotus cuneatus (Con.) Hall (?) ..... (rr)
Lepidodendron sp.

a. ARCHÆOPTERIS OBTUSA LX., CATSKILL, PHŒNECIA, ULSTER COUNTY, N. Y.
b. DETAIL OF PINNULE BETWEEN THE ULTIMATE PINNÆ IN SAME SPECIMEN.
c. DETAIL OF PINNULE OF ULTIMATE PINNÆ.

No. 1478 C1.—On the hill, 2 miles north of west of West Brookville, which is 3 miles northeast of Cuddebackville, is the old Ferris quarry, which is about 610 feet above the canal level, and consequently has an approximate altitude of 1,220 feet A. T., being over 200 feet higher than the Weingardner quarry. The rock is a coarse, gray sandstone with partings of greenish to olive argillaceous shale. No fossils were found. The dip, measured on bed planes in the quarry, is between 18° and 20°, about 40° west of north. The stratigraphic position of this horizon seems to be that of the coarse, greenish gray sandstone of eastern Pennsylvania, named by Prof. White the Starucca sandstone.

No. 1478 C2.—An old quarry, nearly 1 mile up Fall Brook after its junction with the main kill. The quarry stone is gray, coarse-grained sandstone which has a dip of 14° between 30° and 35° west of north. Somewhat below the quarry, loose red shale was noticed which had not been carried from any great distance.

No. 1478 D1.—Wurtsboro, Sullivan County, is 9 miles northeast of Cuddebackville, or 4 miles southwest of Summitville which is on the main line of the New York, Ontario and Western Railroad. Nearly 2 miles northwest of the village and more than 500 feet higher, is the Clark quarry, which was operated by Charles Green in 1891. The flagging is rather coarse-grained, gray sandstone, covered with a considerable thickness of greenish to olive-colored argillaceous shale. The dip of the lowest bed exposed is 19°, while the highest shows a dip of 12° on the bed planes about 20° west of north. The olive shale contains fossil plants, several good specimens of *Archæopteris obtusa* Lx. having been obtained. Mr. Green stated that earlier in removing the stripping, quite a number of excellent specimens of ferns were found, which, unfortunately had been destroyed. Two paleobotanists referred these specimens to *Archæopteris hibernica* (Forbes) Lx., and although my first identification was with *A. obtusa* Lx. it was thought best to confer with a recognized authority in reference to the identification of this species. Two specimens from this quarry were submitted to Sir William Dawson, who wrote: "these specimens are *Archæopteris obtusa* Lx., characteristic of the Upper Devonian. The pinnules on the rhachis [which these specimens have and which Lesquereux gave as characteristic of *A. hibernica* (Forbes) Lx. and *A. Halliana* (Göpp) Lx.][1] occur in different species of *Archæopteris*. These are quite too large for *A. hibernica* and different in form. * * *

"I am very much interested in the large fronds of *A. obtusa*. Would it not be possible in searching the beds, to find the fruit? It should be in oval capsules like that of *A. hibernica*, on special fertile pinnæ."[2] The main difficulty in identifying these specimens arose from comparing them with two specimens kindly loaned me by Mr. Lacoe, one of which was identified by Lesquereux as *A. obtusa* and the other as *A. hibernica;* while my specimens were nearer the *A. hibernica* than the

[1] 2d Geol. Surv. Penn., P 3 (Coal Flora, vol. III), p. 773.
[2] Letter of Sir William Dawson, March 1, 1892.

A. obtusa. Later, these two specimens were sent Sir William Dawson who identified both as *A. obtusa.*[1]

Archæopteris obtusa was described without figure under the name of *Nœggerathia obtusa* by Lesquereux in the Jour. Bost. Soc. Nat. Hist., Vol. VI, 1854, p. 415, as simply from Pennsylvania. The species is figured in the Geol. Penn, Vol. II, pt. II, 1858, pl. I, fig. 11, and on p. 854, Lesquereux states that it is from the "Red sandstone of the Ponent group [Catskill], Lehigh, below the Mauch Chunk Gap." Lesquereux, Am. Jour. Science, 2d ser., Vol. XXXII, 1861, p. 200, stated that he had "lately received from Prof. J. D. Dana, of New Haven, the figure of a splendid specimen of *Nœggerathia obtusa*, found in the old Red Sandstone [Catskill] of Montrose, Pa." A portion of the frond of this fern was figured by Dana in the Man. of Geology, 2d ed., 1875, fig. 557*a* on p. 279. Fontaine, Am. Jour. Science, 3d ser., Vol VII, 1874, p. 578, reported this species from Lewis Tunnel, Virginia, which he then called Catskill, but later changed to Vespertine (Pocono).

Lesquereux (2d Geol. Surv. Penn., P, 1880, Pl. XLIX, Figs. 6, 7, p. 301) redescribed the species under the name of *Archæopteris obtusa*, and changed the age of the locality below Mauch Chunk, from the Catskill to the Vespertine [Pocono].

Dawson, Foss. Plants Erian (Dev.) Up. Sil., Canada, Pt. II, 1882, Pl. XXII, p. 100, under the name of *Cyclopteris obtusa*, reported it from the Upper Erian (Devonian) of Scaumenac Bay, opposite Dalhousie, New Brunswick. Dr. Dawson also stated that he had a specimen from the Catskill, at Franklin [Delaware County], N. Y. [It is probable that the age of the horizon at Franklin is not later than Chemung, although since the exact locality is not given, it may have been from the lower part of the Catskill.] Dawson further states that the specimens from the Middle Devonian shales at St. John, New Brunswick, referred by him to this species (Quart. Jour. Geol. Soc., Vol. XVIII, 1862, Pl. XV, fig. 33, p. 319), belong to a different species, as stated by Lesquereux (2d Geol. Surv. Penn., P, pp. 301, 302), and is renamed *Aneimites obtusa.*

Lesquereux (2d Geol. Surv. Penn., P, Vol. III, 1884, p. 850) reported the species from the Catskill of Meshoppen, Wyoming County, Pa.

The range and distribution of the species may be tabulated as from the Catskill of Montrose and Meshoppen of Pennsylvania; Catskill or Chemung of Franklin, Delaware County, N. Y.; Catskill or Pocono below Mauch Chunk, Pa., and Lewis tunnel, Virginia; and the Upper Devonian of Scaumenac Bay, Quebec.

[1] Letter of Sir William Dawson, March 31, 1892. While studying the species of *Archæopteris*, the writer found another instance of similar identification. In Mr. Lacoe's collection from Meshoppen, Pa., was a specimen identified by Lesquereux as *Archæopteris minor* Lx. In general character this specimen agreed more closely with *A. rogersi* (Dn.) Lx., and the rachis was clearly transversely rugose. In Lesquereux's key to the genus *Archæopteris* (2d Geol. Surv. Penn., P, Vol. III, p. 773), he put *A. minor* under Section B, "rachis striate lengthwise," and *A. rogersi* under Section D, "rachis transversely rugose." This specimen and the type specimen of Meek's *Cyclopteris alleghaniensis* from Virginia, which Lesquereux made a synonym for *A. rogersi* (ibid., P, p. 307), were sent to Sir William Dawson, who wrote me that the Meshoppen specimen "is certainly *A. Rogersi*, but *A. alleghaniensis* is quite distinct." (Letter of Sir William Dawson, March 1, 1892).

The *Haliserites* of Lanesboro, Pa., also occurs in this shale.

Along the quarry road, lower than the quarry, are exposures of red arenaceous shale. Ledges of moderately arenaceous shale occur in the upper part of the village and also along the hill on the western side of the highway, 1 mile north of Olcott's hotel, but no fossils were found. It seems that the fossiliferous rocks of the Hamilton and the lower part of the Portage are covered by the drift which has filled up the old river channel in the region of Summitville. At least no exposures were found containing fossil shells.

SECTION ALONG THE ULSTER AND DELAWARE RAILROAD.

After an examination of the rocks in the Summitville region, the next section crossing the Devonian formations is 25 miles to the northeast, in the vicinity of Kingston.

At Rondout, on the Hudson River, are exposures of Hudson shales and sandstones which extend from part way up the bluff to near the entrance of the quarries in the cement rock. This is a region of decided interest in respect to the stratigraphic geology, since most of the geologists who have studied it regard the Upper Silurian as resting unconformably on the Lower Silurian, while some consider it a fault.[1]

On the bluff above the Ulster and Delaware Railroad station in Rondout are good opportunities for studying the relations of the Hudson shales and sandstones to the overlying limestones. Along the West Shore Railroad south of Kingston are numerous exposures of the limestones and this is an excellent locality to work out the folding as has been so admirably done by Prof. Davis for this, and the same series of formations, farther north.[2]

[1] For the more important papers see J. G. Lindsey, who described the rocks at the Rondout cement quarries, Poughkeepsie Soc. Nat. Sci., Proc., II, 1879, pp. 44-48; T. N. Dale, "The Fault at Rondout," Am. Jour. Sci., Vol. XVIII, 1879, pp. 293-295. On p. 294, figs. 1 and 2 give an excellent representation of the position of the Lower Helderberg beds on the Hudson River shales; William M. Davis, Bull. Mus. Comp. Zool., Geol. Ser., Vol. I, No. X, 1883, pp. 319-323, and on pl. XII see figs. 6, 11, 14, and 15, which give several views of the junction of the Hudson shales with the Coralline and Lower Helderberg limestones, while in the text is a complete review of all the literature in reference to this structure at Rondout.

Prof. Davis contributed a paper on "The Nonconformity at Rondout, N. Y.," to the Am. Jour. Sci., 3d ser., Vol. XXVI, 1883, p. 389, with a map on p. 391, showing the distribution of the different formations in the vicinity of Rondout, crossed by 6 cross-sections, showing the stratigraphic structure of that region. In reference to the exposures in the bluff near the cement quarries at Rondout, Prof. Davis says: "The Hudson River rocks were upheaved, exposed to erosive forces, presumably of the ordinary subaerial kind, and then submerged to receive the later formations on their worn edges. This is most excellently shown in the old quarry in the hill overlooking Rondout, where the contact line has been perfectly exposed for 10 feet or more; a fair inference of nonconformity can be made out at several other points along the slope" (pp. 392, 393). While in a later paper the professor, referring to Rondout, says, "there is a strong unconformity. * * * The contact could not have been made by a fault; it was a distinct unconformity" (Bull. Geol. Soc. Am. Vol. I, 1890, pp. 354, 355).

[2] See paper on the folded Helderberg limestones east of the Catskills, "Bull. Mus. Comp. Zool., Geol. Series, Vol. I, 1883, p. 311; and in particular see Pl. XIII, which gives a map of "The folded Helderberg limestones in Greene County, N. Y.," crossed by fifteen sections showing the geologic structure of the region. Also a paper by the same author, entitled "The Little Mountains east of the Catskills," Appalachia, Vol. III, 1882, pp. 26-33, with Plate I, giving a map of the region, a series of block-sections, general section of the Little Mountain belt, section from the Catskills to the Hudson, and a series of seven special sections.

The first cut is a little more than one-fourth of a mile south of the Kingston station, just below Fitch's trestle, and the northern two-thirds of the cut is through bluish-gray massive limestone with an occasional layer of shale. Fossils are common, especially *Atrypa reticularis* (Linné) Dal. and *Strophomena rhomboidalis* (Wahlenb.) Dav. The rock is much darker in color at the southern end of the cut, has but few fossils, and becomes shaly and arenaceous. At the southern end of the Kingston tunnel on the West Shore Railroad, by the Rondout Creek railroad bridge are light gray limestone layers alternating with dark layers. The light grayish limestone contains abundant fossils and furnishes a most excellent locality for collecting. The light gray limestone at the southern end of the tunnel is regarded as the Catskill shaly limestone with Upper Pentamerus near the middle and, at the northern end, Oriskany. In the cuts nearer Kingston are the Cauda-galli grit and the Corniferous limestone.[1]

When conducting the field work upon which this paper is based, the writer was concerned principally with the Middle and Upper Devonian, and so ran over this section of the Upper Silurian and Lower Devonian in a hasty manner; but the admirable sections and opportunities for studying these formations were noted.

On the Walkill Valley Railroad, 1 mile from Kingston Union station, are exposures of limestones of Lower Helderberg age. About 2 miles from the station is a small cut in blue arenaceous shales (No. 1486 C1) which contains plenty of Hamilton fossils. At this locality the dip is nearly vertical.

The exposures along the Walkill Valley Railroad in the vicinity of Kingston are not numerous, most of the rocks being covered by drift. After leaving Kingston[2] and crossing the valley of Esopus Creek, there are frequent exposures of rocks along the line of the Ulster and Delaware Railroad which give a fair section across the Middle and Upper Devonian formations of Ulster County. The exposures along the line of this railroad will now be described.

The Fair street or Kingston station of the Ulster and Delaware Railroad is said to be on the Lower Helderberg limestone,[3] but no outcrops were observed at that locality. No exposures were found until after crossing the wide valley of Esopus Creek, west of Kingston, and reaching the hill to the west of the creek. There are exposures of black

[1] See note by J. G. L. [Lindsey ?] in MacFarlane's Am. Geol. Rail. Guide, 2d. ed., p. 135, f. n. 152.

[2] The elevation of the eastern terminus of the Ulster and Delaware Railroad at Rondout is 6 feet A. T. (Bull. U. S. Geol. Surv., No. 5, p. 217); the union station in Kingston, of the Ulster and Delaware, West Shore, and Walkill Valley railroads is 186 feet A. T. (ibid., p. 211), and the Fair street, Kingston, station of the Ulster and Delaware, 159 feet A. T. (ibid., p. 211); consequently the difference by railroad levels between Rondout and the union station is 180 feet, and between the union station and Fair street, 27 feet. Several readings of the barometer gave me 175½ feet difference between Rondout and the union station, and between union station and Fair street, 22½ feet, which in both cases is 4½ feet less than the actual difference.

[3] MacFarlane's Am. Geol. Rail. Guide, 2d ed., p. 130, and on "The Geological map of the Middle and Western States, by James Hall" (Geol. N. Y., Pt. IV, 1843), Kingston is represented on the belt colored green, which is stated in the legend to be "Helderberg limestones, including grits and sandstones."

shale by the side of the highway east of the Ulster and Delaware Railroad track after crossing Esopus Creek and about 2 miles west of Kingston station of the Ulster and Delaware Railroad. The rock is a black, very argillaceous shale, which contains only a few fossils and belongs to the Marcellus stage. This outcrop is the second rather prominent ledge by the highway east of the railroad. The first one, just east of the tollgate, is a calcareous rock, which may represent the base of the Hamilton. The elevation of this exposure (1486 D1) is near that of the Fair street station of the Ulster and Delaware, possibly 10 to 15 feet higher.

No. 1486 D2.—First cut on Ulster and Delaware Railroad going west, after crossing Esopus Creek. This exposure, which is west of the Marcellus shales of D1, and perhaps 30 feet higher than the Kingston station on Fair street, is a blue, somewhat calcareous, fine-grained rock, with a conchoidal fracture. The dip is about 5° west of north, as shown in the side of the cut. Only a few fossils were found, *Chonetes* and *Aulopora* (?) being the most abundant.

No. 1487 A5.—In a cut west of the one just described, where the road from Jockey Hill joins the Kingston and West Hurley highway, east of Stony Hollow, are fine fissile shales, weathering to a brown. Lithologically these shales are similar to the Marcellus; but in the next railroad cut, not far to the east, are blocky Hamilton shales.

No. 1487 A4.—The first cut east of Stony Hollow shows rather coarse blue, arenaceous shales, in which fossils are common. The arenaceous layers have a dip of about 5° to the northwest, which is probably near the direction of the greatest dip. The cut is a little higher than Stony Hollow, which is 8 miles from Rondout, with an elevation of 410 feet A. T.[1] *Nuculites oblongatus* Con. is one of the most common fossils in this cut.

FAUNA OF NO. 1487 A4.

Nuculites oblongatus Con	(aa)
Nucula bellistriata (Con.) Hall	(a)
Nuculites triqueter Con	(c)
Paracyclas lirata (Con.) Hall	(c)
Palæoneilo constricta (Con.) Hall	(c)
Modiella pygmæa (Con.) Hall	(r)
Orthonota (?) parvula Hall	(rr)
Spirifera mucronata (Con.) Bill	(rr)
Rhynchonella cf. congregata Hall	(r)
Leiorhynchus multicosta Hall	(rr)
Athyris spiriferoides (Eaton) Hall	(rr)
Chonetes coronata (Con.) Hall	(rr)
Lingula alveata Hall (?)	(c)
Orthoceras constrictum Van. (?)	(rr)
Grammysia, two species, but too imperfectly preserved to identify specifically	(rr)
Bellerophon sp	(rr)
Leptodesma sp	(rr)
Fenestella sp	(rr)

[1] Van Loan's Catskill Mountain Guide, 1890, p. 75.

No. 1487 A3.—Another railroad cut, a short distance west of Stony Hollow, near a switch turning to the north, leading to an old flagstone quarry, and just east of the railroad fill over the swamp. The blue shales are rather blocky and contain fossils.

FAUNA OF NO. 1487 A3.

Nucula bellistriata (Con.) Hall ..... (a)
Nuculites oblongatus Con ..... (rr)
Paracyclas lirata (Con.) Hall ..... (r)
Lingula alveata Hall (?) ..... (rr)

NO. 1487 A2.—BRISTOL HILL.

At the eastern end of the first railroad cut, west of Bristol church, are exposures of fine, blocky, blue shales, in which Hamilton fossils are abundant, the specimens being more numerous than in any of the other outcrops along the line of the railroad. In the long railroad cut to the west, after crossing the trestle, some of the sandstone layers show a dip of between 4° and 5° to the west; while exposures south of the railroad, at the western end of the cut, show that the dip is probably to the northwest.

FAUNA OF NO. 1487 A2.

Chonetes coronata (Con.) Hall ..... (aa)
Eighty-five specimens.
Nyassa arguta Hall. ..... (aa)
Forty specimens.
Nuculites oblongatus Con ..... (rr)
Prothyris lanceolata Hall ..... (rr)
Paracyclas lirata (Con.) Hall ..... (c)
Orthonota (?) parvula Hall ..... (rr)
Microdon (Cypricardella) complanatus Hall ..... (r)
Tropidoleptus carinatus (Con.) Hall ..... (rr)
Cyrtina hamiltonensis Hall ..... (r)
Spirifera mucronata (Con.) Bill ..... (rr)
Spirifera ziczac Hall ..... (c)
Streptorhynchus chemungensis (Con.) Hall ..... (aa)
Forty-three specimens.
Orthis, some of the specimens resemble O. vanuxemi Hall, but others do not appear to be this species and are nearer O. penelope Hall ..... (a)
Palæonielo constricta (Con.) Hall ..... (rr)
Sphenotus truncatus (Con.) Hall ..... (c)
Dalmanites boothi (Green) Hall ..... (r)
Prothyris planulata Hall ..... (rr)
Palæonielo maxima (Con.) Hall ..... (rr)
Schizodus appressus (Con.) Hall (?) ..... (rr)
Actinopteria boydi (Con.) Hall ..... (a)
Twenty-five specimens.
Glyptodesma erectum (Con.) Hall ..... (rr)
Discina sp ..... (rr)

NO. 1487 A1.—WEST HURLEY.

A sandstone quarry of bluish stone in the village just south of the railroad. The dip is 5° or more and about 25° north of west. No fossils were found in this quarry.

From Stony Hollow to about 1 mile west of West Hurley the railroad crosses the main belt of the "Hudson River bluestone." This region is composed of a moderately level plateau of 500 feet or more elevation, and very generally near the surface is a stratum of fine-grained bluish-gray sandstone, in many places lying near the surface for an area of a number of acres. Near the railroad the best quarries have been worked so extensively as to exhaust the supply of good stone, especially in a number of the earlier quarries. The value of this region was described by Mather,[1] at which time the industry had reached considerable proportions, and an additional impetus was given by the opening of the railroads.

Stratigraphically, the lower portion of these quarries belongs in the Hamilton, and the upper part of the belt in the Portage, while the quarries still higher are in the Catskill, as stated by Prof. Smock in 1888.[2]

No. 1487 B1.—The Hurley Stone Crushing Company's quarry, formerly called Lawson's quarry, is one-half mile west of West Hurley. The quarry was formerly worked extensively for flagging stone, which has been mainly taken out, the stripping rendering it now unprofitable to work. Prof. Smock says where the stripping "is over 20 feet the quarry beds must be thick and the stone of good quality to pay for its removal. A rule is that the total thickness of quarry beds must not be less than one-third of the stripping."[3]

A New York company has been formed, called the "Hurley Stone Crushing Company," which has put in a crusher, and proposes to crush the waste stone on the dumps for road material. In this region there is an immense amount of this waste rock on the old dumps which is available for such purposes. The rock of the Lawson quarry is mainly the blue rather thin-bedded sandstone, part of which has a tendency to weather to a reddish tint, and is separated by partings of shale. In places a good many clay concretions are present, and glacial striæ show on the top of the sandstone layer at the surface, running nearly northeast and southwest. On the south side of the eastern part of the quarry there is a dip of about 6°, 40° north of west. By the barometer

[1]Geol. N. Y., Pt. 1, 1843, pp. 318, 319.

[2]Bull. N. Y. State Mus. Nat. Hist., vol. I, No. 3, March 1888, pp. 17-19. The distribution of this belt, location of the quarries, and character of the rock are also fully described (ibid., pp. 71-78). Much of this data is repeated, with some additional information, by Prof. Smock in a later bulletin (ibid., vol. II, No. 10, 1890, pp. 222-225, 265-271), while a considerable part of the information was first published in the "Report on the Building Stones of the United States," Tenth Census of the U. S., vol. X, pp. 130-134.

[3]Bull. N. Y. State Mus. Nat. Hist., No. 3, p. 74.

the quarry is about 150 feet higher than the railroad station at West Hurley, which makes an approximate altitude of 680 feet A. T.[1]

On the south side of the northeastern part of the quarry is a shaly parting from less than 1 to more than 2 feet in thickness, between layers of heavy sandstone. This shale in places contains *Psilophyton princeps* Dn. in abundance. Fossil plants occur in the massive sandstone and in the large excavation south and southwest of the one with the shale, but still, east of the highway is a sandstone stratum in which some of the best Hamilton fossil plants that I have ever seen were collected. Some of these specimens have been examined by Sir William Dawson and Prof. D. P. Penhallow, and their observations in connection with my own will be given.

From Lawson's quarry at West Hurley several good specimens of *Lepidodendron gaspianum* Dn. were obtained, one of which Sir William Dawson has seen and identified as above. The upper branches of one of the larger specimens show a few leaves along their sides. Some of the decorticated upper branches show clearly the elliptical depressed areoles, not contiguous, in some of which indications of a central scar, sometimes elongated, are preserved. These characters agree closely with Dr. Dawson's specific description where it was stated, — "Decorticated specimens, slightly compressed, show elliptical depressed areoles, not contiguous, and with only traces of the vascular scars."[2] The bibliography and references to range and distribution of this species were recently published,[3] and I will simply quote here the conclusions as to the range and distribution of the species. It is reported "probably from the Corniferous limestone of Ohio; Middle Devonian of Gaspé and New Brunswick; Hamilton, Genesee, Portage, and Chemung (?) of New York; Chemung (?) of Pennsylvania; Upper Devonian of Maine and Gaspé; Pocono possibly of Virginia, and Huntingdon County, Pa.; Subcarboniferous doubtfully of Ohio, and Crawford County, Pa.; possibly in the Lower Devonian of Belgium, and Devonian of France."[4] The New York State Museum at Albany contains specimens labeled *Lepidodendron gaspianum* from the Hamilton of Schoharie County, N. Y., Genesee shale of Moravia, N. Y., and a large specimen from the Hamilton stage of Gilboa, Schoharie County, N. Y. The American Museum of Natural History, Central Park, New York, also contains a specimen labeled, "Summit, Schoharie County, N. Y., and probably of Hamilton age.

[1]The altitud of West Hurley is given as 534 feet in MacFarlane's Am. Geol. Rail. Guide, 2d ed., p. 130. Prof Guyot quoting the records of the Ulster and Delaware Railroad survey, gives 540 feet for West Hurley (Am. Jour. Sci. 3d ser., Vol. XIX, p. 449); while in a guidebook on the Catskill Mountain issued by the Ulster and Delaware Railroad, in 1890, it is given as 540 feet on p. 31, and as 530 feet on p. 56; but Van Loan's Catskill Mountain Guide, 1890, p. 75, gives the elevation as 530 feet

[2]Quart. Jour. Geol. Soc., Vol. XVIII, 1862, p. 313; in describing fig. 26, of Pl. XIV.

[3]Prosser; Trans. N. Y. Acad. Sci., Vol. XI, 1892, pp. 144-147.

[4]Op. cit., p. 147.

In addition to the above species, Sir William identified one specimen as *Lepidodendron primævum* Rogers, "the Knorria form."

Lepidodendron primævum was figured and named by Prof. H. D. Rogers in the Geology of Pennsylvania,[1] from the Cadent series [Hamilton] at the mouth of Standing [Stone] Creek, east of Huntingdon, Pa. Lesquereux[2] reported the age of the specimen as Marcellus, while Prof. I. C. White gave the horizon of the rocks at the mouth of this creek as Genesee;[3] finally Rogers' figure is reproduced by Prof. Lesley in his final report under the head of "Hamilton sandstone fossils."[4] There are, however, paleontological reasons for considering the age of these rocks as of the Upper Hamilton stage rather than the Marcellus or Genesee.

Dawson[5] reported "a *Lepidodendron*, obscurely preserved, but apparently of the type of *L. Veltheimianum*, and possibly the same with *L. primævum* of Rogers," from the Upper Devonian (supposed Genesee shale) of Kettle Point, on Lake Huron, Ontario, Canada.

Dawson[6] states that there are fragments of a *Lepidodendron*, which seem to belong to this species, in the Portage of Milo, Yates County, N. Y.

Dr. J. M. Clarke[7] reports this species from the *Styliola* layer of Ontario County, N. Y., and at Black Point, Canandaigua Lake, Ontario County, N. Y., both in the Genesee shale. Also from the Naples (Portage) at Naples, Ontario County, (the remarkable specimen now in the New York State Museum at Albany having been obtained from Grime's Gully near Naples); and from the township of Sparta, Livingston County.[8] The occurrence of this species in the Genesee and Portage of Ontario County, is again mentioned by Dr. Clarke,[9] who states that Dr. Dawson identified the specimens from the *Styliola* layer.[10]

Dr. Clarke[11] published a letter giving a general description of the Naples specimen, in which he said "if it had been found in fragments, taken from different spots, it would furnish all the necessary material for a half dozen distinct species of *lepidodendron*, according to prevalent methods of determining these values. Moreover, toward the base, the leaves are uniformly arranged on elevated longitudinal ridges, as in *Sigillaria*, showing nothing of the quincunx arrangement, apparent higher up, and regarded as a diagnostic character of *lepidodendron*. In this region, also, the longitudinal ridges are interrupted by a series of varices, suggestive of an equisetaceous mode of growth." This specimen was found by Mr. D. D. Luther and sold to the New

[1] Vol. II, Pt. II, 1858, pp. 828, 829, fig. 675 on p. 828.
[2] 2d Geol. Surv. Penn., P. 1880, p. 377.
[3] Ibid., T[3], 1885, p. 261; and see the map of the vicinity of Huntingdon on p. 256.
[4] Ibid., Sum. Desc. Geol. Penn., Vol. II, 1892, p. 1284.
[5] Am. Jour. Science, 3d Ser., Vol. I, 1871, p. 258.
[6] Quart. Jour. Geol. Soc., Vol. XXXVII, 1881, p. 302.
[7] Bull. U. S. Geol. Surv., No. 16, 1885, pp. 25, 26, 33.
[8] Op. cit., pp. 63, 64.
[9] Rept. State Geol. [New York] for 1884, 1885, pp. 18, 19, 21.
[10] Op. cit., p. 18, f. n.
[11] Science, Vol. IX, May 27, 1887, p. 516.

York State Museum at Albany. It is a magnificent specimen, showing the large base with roots and gradually tapering stem of a tree of considerable size, and certainly deserves careful study, with illustration and description.[1]

The range and distribution of the species may be stated as follows: Hamilton of Huntingdon, Huntingdon County, Pa.; the Genesee of Canandaigua Lake, New York, and possibly in the same formation on Lake Huron, Ontario; in the Portage at Naples, Ontario County, and Sparta, Livingston County, N. Y.; also probably in the same formation at Milo, Yates County, N. Y.

Lepidophloios antiquus Dn. was described and figured in Foss. Plants, Dev. and Up. Sil. Formations, Canada, 1871, p. 36, Pl. VIII, figs. 90, 91, from the Middle Devonian of Gaspé. Also see the statement that "Leaves, apparently of a very small species of Lepidophloios are found rarely in the shales of St. John. They may possibly belong to the present species." The West Hurley specimen was identified by Sir William Dawson, and as far as I know, it is the first identification of this species in the United States.

Psilophyton princeps Dn. occurs in considerable abundance. The bibliography, distribution, and range of this species may be found in a recent publication.[2]

It was stated that *Psilophyton princeps* Dn. "is most abundant in the Lower and Middle Devonian, but also ranges from the Upper Silurian to the Upper Devonian of Gaspé, occurs in the Upper Devonian of eastern New York (doubtful Catskill) and is reported from the Subcarboniferous (Waverly) of Ohio."[3]

In the Lawson quarry are a great many specimens which, though resembling *Psilophyton princeps* Dn. in some respects, differ in others, and may be simply fern stipes. Some of the specimens, however, are clearly this species, as is shown by comparing them with specimens from Canada, labeled, and sent me by Sir William Dawson, or with specimens from Haines Falls, Green County, which, upon being submitted to Sir William Dawson, were identified as *Psilophyton princeps* Dn.[4] On one slab from this quarry are a considerable number of approximately parallel stipes, which are nearly flat and show very little structure. The branching is opposite, a few of the branches are about 1¼ inches (3 cm.) in length, but most of them are not more than one-half inch in length where they are broken off. On the stipe which arises from the rhizoma the first branch is 1½ cm. from the rhizoma; then the distance between the first and second and the second and

[1] For a brief notice see Dr. Clarke in Bull. U. S. Geol. Surv., No. 16, 1885, pp. 63, 64.

[2] Prosser: Trans. N. Y. Acad. Sci., vol. XI, 1892, pp. 139-142. The locality of Cascade Falls was in doubt when the above paper was written, but there are specimens in the State Museum at Albany, labeled "Rhizomes of Psilophyton, Cascade Falls, Ithaca, N. Y.," which, if not the specimens identified by Dr. Dawson, probably came from that locality. The geologic age of these specimens is therefore probably the Ithaca group.

[3] Op. cit., p. 142.

[4] Am. Geol., vol. VII, 1891, p. 365.

third branches is about 5½ cm.; and between the third and fourth and the fourth and fifth is 4¾ cm. The stipes near the base are 2 mm. in width. The upper part of some of the stipes, where the coaly material is not completely gone, shows the leaf scars and also the longitudinal ridges. At the bottom of the slab is a piece of the rhizoma to which one of the stipes is attached. On the upper and longer side, it is 4 cm. in length, and the width is 6 mm. On the rhizoma a little below the origin of the stipe is a circular marking which may be an areole. This is the best specimen of *Psilophyton princeps* Dn. yet seen from the Hamilton of New York. Dr. Dawson stated in the specific description that the stems were "covered with interrupted ridges,"[1] and this character is very clearly shown on specimens sent me by Dr. Dawson from the Lower Devonian of Campbellton, New Brunswick; but on most of the New York specimens this character is not very distinct and some of the stipes are nearly smooth. However, some of the specimens from the Lawson quarry are clearly ridged, though not quite so strongly as the Canadian specimen. A number of these specimens resemble quite closely the plant figured by Vanuxem[2] from west of North New Berlin (now New Berlin), Chenango County, and consequently in the upper part of the Hamilton stage, which was published by Prof. Hall as *P. princeps*.[3]

In the State Museum at Albany is a specimen labeled Hamilton, North New Berlin, N. Y., which may be one of those collected by Vanuxem. The specimen has a rather large stem, with one branch from which a number of small branchlets arise. This specimen is very similar to, though somewhat smaller than, those collected by myself at Skunnemunk Mountain, Orange County, West Hurley, Ulster County, and Haines Falls, Greene County, N. Y. In the collection of the American Museum of Natural History, Central Park, New York, is a large branched stem labeled "*Psilophyton princeps* Dn. Schoharie County, N. Y."

In addition to the species already mentioned, specimens of a large and interesting fossil plant were obtained, which on study proved difficult of identification. Sir William Dawson, upon examination of these specimens, decided that they had not been described. Prof. Penhallow also regarded them as new, and named and described the species as *Psilophyton grandis*.[4]

No. 1487 D.—Garry ledge. These quarries are 2 miles north of West Hurley with exposures in places of 12 feet of bluestone, part of which is flagging, covered with nearly 15 feet of reddish and greenish argillaceous shales, some of which are arenaceous. In the shale are fossil plants, probably *Psilophyton*, but they are not clearly preserved. The

[1] Foss. Pl. Dev. and Up. Sil., Pt. I, p. 37.

[2] Geol. N. Y., Pt. III, p. 161, fig. 40.

[3] Sixteenth Regents' Rept. on State Cab. Nat. Hist., 1863, p. 110. Vanuxem's figure is reproduced on p. 111, fig. 2.

[4] Proc. U. S. National Museum, vol. XVI, pp. 111–113, Pl, XII, fig. 12a; Pl. XIII, fig. 12b; Pl. XIV, fig. 12c.

large excavation shows a dip of nearly 3°, 35° east of north; but the joint gives a greater dip west of north.

No. 1487 C4.—Formerly Lewis and Goodwin, now Lockwood quarry. This quarry is a few rods south of the railroad, 1¾ miles west of West Hurley, or 1¼ miles east of Olive Branch. The sandstone is the bluestone, with very few fossils. The bottom of the quarry is a little lower than the railroad track at this point.

No. 1487 C1.—OLIVE BRANCH.

There is a small quarry north of the railroad station, on the right-hand road just beyond the church, which is composed mostly of thin-bedded blue sandstone, with a few shaly partings which contain clay pebbles and specimens of *Psilophyton;* also large plant stems and fragments of fossil wood. This quarry is 18 or 20 feet above the railroad station, which has an altitude of 511 feet. A little farther east by the sawmill and fork in the road is a larger quarry of the blue sandstone (No. 1487 C2). Nothing but plant stems and fragments of fossil wood were found in this quarry. One-fourth mile farther east is an outcrop of red shale by the roadside (No. 1487 C3).

No. 1488 B3.—OLIVE CITY (POST-OFFICE, OLIVE BRIDGE).

Along Esopus Creek below the bridge are several quarries that have been worked to some extent in a bluish flagging stone, which in places has a slightly grayish tint. The quarry stone is capped by an olive shale. A fragment of a *Lepidodendron* and plant stems were observed in the most southern of these quarries, but with this exception very few fossils were found. In the creek below the quarries are slabs of blue sandstone with beautiful ripple marks, while above the falls and bridge, mottled red and green shales occur. These quarries are near the top of the series of "bluestone" and 30 or 40 feet lower than the railroad station at Brodhead's bridge, which is 500 feet A. T.

Bessemer's quarry, near the foot of High Point Mountain (1488 B5), is 2½ miles from Olive City. The stone is a massive, bluish-gray, rather coarse-grained sandstone, which weathers partly to a reddish tint and partly to a darker gray. Clay pebbles occur in some of the layers, and a few fragments of plants were seen. On the road leading up the foot of the mountain to the quarry are reddish shales, and near the base of the mountain, blocks of stone with cross bedding, very similar to the stone farther up the railroad near West Shokan.

No. 1488 B2—BRODHEAD'S BRIDGE.

In the bed of Esopus Creek just below the railroad bridge is bluish-gray massive sandstone, below which is first, a mottled chocolate and olive argillaceous shale, then a clear olive argillaceous shale, and at the bottom a gray sandstone like the upper sandstone.

No. 1488 C1—SHOKAN.

Exposure in brook, just below the post-office in Shokan village, of bluish-gray sandstone, with reddish shales a little farther up the brook. Ripple marks are common on the surface of the sandstones, and in addition are rather odd markings vertical to the bedding. The railroad station at West Shokan, across Esopus Creek, is 533 feet, and the altitude of this exposure is not much less than the railroad level.

No. 1488 D1.—A ledge near the south margin of Little Mountain, 2 miles from West Shokan, and well toward its summit. The ledge is a coarse-grained massive sandstone, about 790 feet above railroad level at West Shokan, which makes its elevation approximately 1,323 feet A. T. The summit of Little Mountain by barometer is 825 feet above railroad level at West Shokan, or, approximately, 1,358 feet A. T.

Burgher's quarry, No. 1488 D2, on the southern side of Little Mountain, is about 715 feet above railroad level at West Shokan, or, approximately, 1,248 feet A. T. The rock is a bluish-gray coarse-grained sandstone, which is rather massive, although some flags have been taken out. There is a shaly layer which in places is a blue argillaceous shale, containing plant stems, while fragments of fossil plants occur occasionally in the massive sandstone.

No. 1488 A1.—Quarry 2½ miles up the Ulster and Delaware Railroad from West Shokan and 1 mile up the mountain to the west. Bluish-gray rather coarse-grained sandstone, with shaly layers which contain abundant poorly preserved plant stems. The quarry is 565 feet above the railroad track at the switch.

No. 1489 B1.—BOICEVILLE.

The Avery quarry is three-fourths of a mile north of Boiceville and one-fourth mile up the hill west of the railroad. It is a massive, bluish-gray sandstone with arenaceous shales, in which are numerous poorly preserved plant stems. One fairly well preserved fragment of *Lepidodendron* was also found. Boiceville is 615 feet A. T., and this quarry is approximately 850 A. T.

Cushley quarry, No. 1489 B3, is on the south side of Cold Brook Mountain. The stone is principally a massive, bluish-gray sandstone. There are also layers of pinkish stone, which make a good thin flagging, and near the middle of the ledge is a shaly layer with some clay pebbles. The stone has a rather greenish matrix which weathers to a brown. There is a dip of between 5° and 6° between west and northwest. On the outcrop of one of the old quarries, a little farther north, an occasional white quartz pebble, with the clay pebbles, was seen. These quarries also have plenty of red shale and reddish sandstone. The altitude of this quarry is approximately 1,350 feet A. T.

No. 1489 A1.—MOUNT PLEASANT.

In a railroad cut three-fourths of a mile south of Mount Pleasant is a good exposure of chocolate-colored shales and sandstones. The shales are very argillaceous and contain the fucoid (?) markings so generally seen in the red shales of the Catskill region. The olive to greenish-gray coarse-grained sandstone also occurs in close connection with the red sandstone, as on the eastern side of the track at the south end and under the red. This may be regarded as a good exposure of the "Oneonta" reds. At one point in the cut is a dip of between 3° and 4°, about 15° west of north, while at the southern end the dip is 3°, 5° east of north, showing a small anticline in this cut. Mount Pleasant is 3 miles north of Boiceville, with an altitude of 700 feet, and the cut has an approximate altitude of 685 feet A. T.

No. 1489 A2.—The Nelson Lane quarry is immediately above the southern end of the railroad cut just described. The stone is the dark, bluish gray sandstone, which is in layers of a foot or more in thickness, except in the upper part of the quarry, where there are layers of stone 3 inches in thickness that make good flagging. The exposure is 25 feet in thickness, the massive sandstone strata being separated by shaly layers, in which are clay pebbles; and in one of them, near the middle of the ledge, are numerous clay pebbles in association with an occasional white quartz pebble. Pieces of fossil wood and plant fragments are quite common, and one piece of *Lepidodendron* with clear markings was found. The greatest dip is toward the northwest, and the quarry is about 115 feet above the railroad, or with an approximate altitude of 800 feet A. T. There is a great deal of cross bedding in this ledge, similar to that figured by Vanuxem for the Catskill.[1] By the quarry road leading down the hillside, and a little lower than this quarry, is another opening in a similar sandstone, below which occurs the red shale and sandstone.

PHŒNICIA.

No. 1490.—On the western side of the railroad, from Boiceville to 1 mile north of Phœnicia, there is no break in the mountains, and at Phœnicia, where the Stony Clove Creek enters Esopus Creek from the northeast, the two valleys are very narrow with steep mountain slopes on either side. This region forms a charming summer resort and is much frequented. Near Phœnicia on the sides of the steep mountain slopes are numerous ledges of grayish sandstone in which a number of quarries have been opened, and at present Phœnicia is one of the most important shipping points for flagging stone on the line of the Ulster and Delaware Railroad.

No. 1490 A1.—The Baldwin quarry is on Mount Romer, one-half mile southwest of Phœnicia. The stone is mainly a bluish gray sand-

[1] Geol. N. Y., Pt. III, fig. 53, p. 187.

stone which weathers to a gray and becomes harder. Interstratified with the quarry stone are layers of red shale and sandstone. The red blocky shales contain large numbers of the fucoid (?) so common in the red shales of the Oneonta and Catskill stages. There is also a "pudding-stone" layer composed of different materials, clay pebbles with some quartz pebbles, and the whole mass is firmly solidified. In a blue argillaceous shale plant stems were found, also three rather imperfect fronds of *Archæopteris*. This quarry is barometrically 240 feet above the railroad station at Phœnicia, which is 798 feet A. T., so the quarry is approximately 1,038 feet A. T.

No. 1490 A2 is a ledge, not worked at present, farther up Mount Romer and above the Baldwin quarry. The floor of the quarry is a pinkish sandstone, above which is the bluish gray, coarse-grained sandstone. There are also the usual irregular shaly layers, in some of which are fragments of ferns. This quarry is 440 feet above the railroad barometrically, or with an approximate altitude of 1,238 feet A. T.

Farther northwest, near the top of Mount Romer, about three-fourths of a mile nearly west of the railroad station, is the McGraw quarry (1490 C2), owned by Mr. John L. McGrath, of Phœnicia. This quarry is 500 feet above the railroad by the barometric reading, or with an approximate altitude of 1,298 feet A. T. The stone is mostly a bluish gray sandstone with an occasional pink tint, and is separated by shaly partings. Near the southern end of the quarry fragments of *Archæopteris* in bluish rather arenaceous shales were found

No. 1490 B1.—The Boice quarry is on Tremper Mountain, 1¼ miles southeast of Phœnicia. The stone is bluish gray, which weathers to a pure gray, and the layers thicken and thin out very irregularly. There is reddish shale and blue which weathers to an olive, argillaceous shale, in which are fossil plants; a few specimens of *Archæopteris* having been obtained. The quarry is between 150 and 160 feet above the railroad, or with an approximate altitude of 950 feet A. T.

No. 1490 B2.—Winnie and Wolvern's quarry is farther up the mountain than the Boice quarry. It is composed largely of the bluish gray sandstone; but in the lower part of the upper half is a layer of bluish argillaceous shale which is very smooth and contains no fossil plants. Large quartz pebbles were seen in nearly clear sandstone. This quarry is about 430 feet above the railroad, by the barometer, or with an approximate altitude of 1,230 feet A. T.

No. 1490 B3.—Winnie and Murphy's quarry is still farther up the mountain, being some 700 feet above the railroad, or with an approximate altitude of 1,500 feet A. T., and is 1½ miles southeast of Phœnicia. The stone is mainly the bluish gray sandstone, rather thin-bedded, though there is some of the pink sandstone. There is a little argillaceous shale, which is very generally called "pencil" by the quarrymen. No fossils were found.

No. 1490 D1.—The McGrath or "old gold mine" quarry is the

southern one on the western side of Mount Sheridan, 1 mile northwest of Phœnicia, and is now worked by Mr. John D. McGrath. The back of the quarry in places is nearly 60 feet high, and a large amount of stone has been taken out. The good stone is the pinkish and bluish gray sandstone, but on the dump is a large amount of the bluish shale, which weathers to an olive color. In some of the rather arenacious slabs were excellent specimens of *Archæopteris obtusa* Lx., in fact the best that have been found at any locality in the Oneonta or Catskill rocks. Sir William Dawson has expressed much interest in the photograph of one of the large specimens which is figured in this work (See Pl. II, figs. *b*, *c*). In the more argillaceous shales were found a few pinnules of *Archæopteris sphenophyllifolia* Lx. (?). The quarry is about 370 feet above the railroad, or with an approximate altitude of 1,170 feet A. T.

Farther north, along the same ledge, is the Ryder quarry (1490 D2), with bluish-gray and pink sandstone. This quarry contains a rather prominent stratum of the "flint rock" of the quarrymen, which is the "pudding stone" that in this quarry contains a good many quartz pebbles in addition to those of clay. A little of this stratum was seen in the McGrath quarry, but the Ryder quarry does not show the plant-bearing stratum.

NO. 1493 A1.—ALLABEN.

Risley quarry, which is not worked at present, is one-fourth of a mile southeast of Allaben, on the western side of the railroad. The lower part is massive bluish gray sandstone and the top red shale, containing plenty of fucoid (?) markings. The altitude of Allaben is 990 feet, which is about that of the quarry.

NO. 1492 A1.—BIG INDIAN.

This quarry is near the summit of the hill, one-half mile north of the railroad station. The bed rock is a pink sandstone, above which is the bluish gray sandstone, a layer of the pebble rock, and some bluish shale. Specimens of *Archæopteris* are found in the shale. The quarry, which is not worked at present, is about the last one on the Ulster and Delaware Railroad until after passing the summit and approaching Griffin's Corners. The quarry is 550 feet above the railroad, which is 1,209 feet A. T. at Big Indian, making the altitude of the quarry approximately 1,760 feet.

Five miles beyond Big Indian and 41 miles from Rondout is the Grand Hotel station, where the summit of the railroad is reached at 1,886 feet A. T. The ascent of the hill back of the Grand Hotel is made over strata of coarse gray sandstone, alternating with red sandstone and shale. The field on the summit, which is about 565 feet above the railroad station, or, approximately, 2,450 feet A. T., is appar-

ently underlain by red shale and sandstone, but the rather prominent ledge on the western side of the hill is composed of the coarse gray, fine-bedded sandstone. These exposures from Phœnicia to the summit are characteristic deposits of the Catskill stage of southeastern New York.

SECTIONS IN CATSKILL MOUNTAINS, GREENE COUNTY, N. Y.

When the summit of the Ulster and Delaware Railroad was reached at the Grand Hotel station, where the rocks are well up in the Catskill stage, I returned to Phœnicia and followed the line of the Stony Clove and Catskill Mountain and Kaaterskill railroads to Kaaterskill station, which is less than 1 mile from the eastern face of the Catskill Mountains at the Catskill Mountain House, above Palenville.

About Lanesville, 5 miles from Phœnicia, are a number of small quarries, but none are worked to any extent. The Barber quarry, No. 1058 P1 on the land of Lane and Barber, about 1 mile southwest of Lanesville, contains at the base bluish-gray sandstones, then a layer of blue shale which has some clay pebbles; above this, thin-bedded sandstones, and on top the pink sandstone. There are masses of plant stems on some of the shaly rock, and many of the sandstones contain branching fern stipes, but no pinnules are preserved.

Lanesville railroad station is approximately 1,350 feet A. T., estimating by the reading of barometer from Phœnicia, and this quarry is some 350 feet higher, or about 1,700 feet A. T.

Toward the foot of the hill, not far from Mr. Lane's "cold spring," is an old quarry (1058 P3) of reddish sandstone. Some of the reddish, arenaceous shales contain fragments of *Archæopteris*, but no good specimens were found. In this quarry, or the small excavation in the bluish-gray sandstone and shale by the "cold spring," Mr. Gilbert van Ingen secured quite good specimens of *Archæopteris*.

Across the valley, northwest of Lanesville station, is a quarry (1058 Q1) composed of bluish-gray sandstone and blue shale. In the shale are plant stems and fragments of *Lepidodendron*.

Farther up the side of the mountain, on Mr. Barber's farm, is another small quarry (1058 Q2) about 300 feet above railroad level, or, approximately, 1,650 feet A. T. The stone is the pink sandstone, alternating with red shale. On part of the sandstone slabs in the upper portion of the quarry are the best specimens of the fucoid (?) markings of these red rocks that have been found. One of the best of these specimens is now in the U. S. National Museum at Washington. This shows a plant of comparatively large size, with base of stem, large stipe, and numerous branches. This specimen is regarded as belonging to *Halisérites*, by one paleobotanist, while it resembles in some characters specimens of *Chondrites* as *C. lanceolatus* Ldwg.,[1] or compare *Palæophycus gracilis* Ldwg.,[2] which in branching and general appearance is

[1] Paleontographica, Vol. XVII, No. 3, 1869, Pl. xix, fig. 6, p. 112.
[2] Ibid,, Pl. 18, fig. 6, p. 111.

quite similar to this specimen, but the base is entirely different from the Lanesville specimen since it has a broad root with several stalks rising from it. Nathorst has figured and described somewhat similar markings as the trails of worms.[1]

No. 1058 R1.—The North quarry, 1½ miles up the Hollow Tree Branch, north of Lanesville, is on the western side of the creek, and shows mainly pink sandstone with a little red shale and gray sandstone on top. No fossils were found, and the quarry is some 300 feet above the railroad, or, approximately, 1,650 feet A. T. About 150 feet higher on the mountain side is another small quarry of pink sandstone with a little bluish shale.

No. 1494 A1.—Simpson quarry, just above Edgewood, is mainly the pink sandstone. This quarry is 3 miles northeast of Lanesville, about 470 feet higher, or with an approximate elevation of 1,820 feet. In the bed of Stony Clove Creek, just above Edgewood railroad station, is a fine exposure of the red shale.

No. 1494 B.—In the "notch" on the eastern side of the railroad, about one-fourth of a mile south of the Stony Clove station, is the Eldredge quarry. In the upper part is very dark bluish-gray sandstone, and in the lower, the pink sandstone. The sandstone is coarse grained, very compact, and contains no fossils. Loose blocks of conglomerate with quartz pebbles are present. This quarry is on the western side of Plateau Mountain, and nearly 130 feet higher than the Stony Clove switch, which is 2,071 feet A. T.,[2] making the approximate altitude of the quarry 2,200 feet A. T.

No. 1495 A.—HAINES FALLS, GREENE COUNTY.

In Twilight Park, near the foot of Round Top Mountain, on the western side of Kaaterskill Creek and Haines Falls, is a prominent ledge of conglomerate (1495 A2). Some of the pebbles are very large and the stratum forms a conspicuous feature of the mountain side, being called locally the "pudding stone." This massive conglomerate is well up in the Catskill stage, and is lithologically about the same as the conglomerate noted by Mather on South Mountain, between Hotel Kaaterskill and the Catskill Mountain House,[3] which he referred to the "lower grits of the Coal formation," evidently regarding them as above the Catskill division. This ledge is by the barometer 110 feet above Haines Falls which, according to Guyot, are 1,890 feet, A. T.,[4] making its elevation approximately 2,000 feet A. T.

In the creek, under the bridge above the Haines Falls (1495 A1), are red sandstones. Below, at the brink of the falls and in the side of the

[1] See Om några förn. Växtfoss., Pl. 18, fig. 11, 12, in Öfversigt af Kongl. Vetenskaps-Akad. Forh., Stockholm, 1873.

[2] Van Loan's Catskill Mountain Guide, 1890, p. 78. Guyot seems to have been in error in assigning this locality an elevation of 1,700 feet. (Am. Jour. Sci., 3d ser., Vol. XIX, p. 435).

[3] Geol. N. Y., Pt. I, 1843, p. 303.

[4] Am. Jour. Sci., 3d. ser., Vol. XIX, p. 449.

cliff, is the bluish-gray sandstone, reaching down to about the middle of the falls, where there is a stratum of red shale and sandstone, then bluish-gray sandstone, and at the bottom of the falls another stratum of the red shale and sandstone. The bed of the creek at the foot of Haines Falls is about 125 feet below the beginning of the stairway at the top of the ledge above. The upper part of the first cascade below Haines Falls is composed of gray sandstone, in one stratum of which are quite large pebbles, and red argillaceous shale, below which at the base is mainly red sandstone. Below this is another cascade, with gray sandstone at the top and red shales and sandstones at the bottom.

At the bottom of the series of cascades is a stratum of red shale, above which is a bluish shale, weathering to an olive color, which passes into the coarse gray sandstone as we reach the top. In the lower part of the shale the structure is rather irregular, perhaps slightly concretionary, and fossil plants were found. This stratum (No. 1495 A—1) is in place at about the middle of the ladder on the lowest ledge, under the massive sandstone, while a little farther down the path are loose blocks which have fallen down the bank, thus affording an excellent opportunity to hunt for fossils. The stratum is about 275 feet below the top of Haines Falls, or it has an approximate altitude of 1,615 feet A. T. The majority of the fossil plants in this stratum belong to *Psilophyton princeps Dn.*, specimens of which were submitted to Sir William Dawson, who agreed to the above identification.[1]

It is difficult to locate the position of this stratum in Sherwood's measured section of the Kaaterskill Clove and Round Top Mountain;[2] but if his section began near the Palenville Hotel and Prof. Guyot's altitudes be correct,[3] then it would seem to be near the 29-foot bed of coarse gray sandstone, No. 121 of his section,[4] the bottom of which is 922 feet above the base of Sherwood's section. This horizon, according to Ashburner's interpretation of the series, is well up in what he calls the "red beds" of No. IX, or the Catskill stage. Ashburner regarded the upper 1,412 feet of this section, forming the upper part of Round Top Mountain, as belonging to No. X of the Pennsylvania Survey,[5] the Pocono or Vespertine, while Prof. Hall regarded 800 or 900 feet of the upper part of Round Top as of Vespertine age.[6] At this time Prof. Hall described a geological section from Schenevus, Otsego County, across

[1] See the following note from Sir William in reference to these plants: "So far as I can make out, most of the plants are *Psilophyton princeps*. One seems to have sporocarps attached, and the broader stems are, I suppose, rhizomata." (Am. Geol., Vol. VII, p. 365, f. n. §.)

[2] Proc. Am. Phil. Soc., Vol. XVII, 1878, pp. 346, 347. In connection with this section see Ashburner's interpretation in 2d Geol. Surv. Penn., F, 1878, pp, 218, 219; and Prof. Hall's account in the 28th Rep. N. Y. State Mus. Nat. Hist., 1879, pp. 14, 15.

[3] 680 feet for the Palenville Hotel and 1,890 feet for Haines Falls (Am. Jour. Sci., 3d Ser., Vol. XIX, p. 449), which would make the altitude of the plant bed (1495 A — 1) about 935 feet above the level of the Palenville Hotel.

[4] Proc. Am. Phil. Soc., Vol. XVII, 1878, p. 346.

[5] Second Geol. Surv. Penn., F, pp. 218, 219.

[6] Proc. Am. Assoc. Adv. Sci., Vol. XXIV, B, 1876, p. 83, and 28th An. Rep. N. Y. State Mus. Nat. Hist., 1879, p. 15.

the Catskill Mountains to Glasco, Ulster County, and gave the thickness of the different formations as follows: "The lower beds shown, of Portage and Chemung, have a thickness of more than 2,000 feet; while the red rocks above, which may be referred to the Catskill, are about 3,000 feet thick, and the higher beds, of Vespertine, extending to the summit of Round Top, may be reckoned at about 800 feet."[1]

The ledge in front of the Catskill Mountain House, overlooking the Hudson, is the coarse gray sandstone of the Catskill stage, as stated in 1843 by Mather.[2] Mr. N. H. Darton has published a section "west of Palenville," on which the lower dark shales are called "Hamilton group," with the "Oneonta beds" immediately above, on which rests the "Catskill group."[3]

In the text it is stated that the Chemung "becomes harder and coarser eastward, and was traced to and along the eastern front of the Catskill Mountains, its base defining the upper limit of the Oneonta formation. Its thickness averages about 250 feet. It is overlain by a red shale bed 25 to 30 feet in thickness, and this, in turn, is overlain by the thick mass of hard gray sandstone on which the old Mountain House is built. At a point about 4 miles due west of Durham, some molluscan remains were found in a softer gray bed about 175 feet above the summit of the Oneonta formation. One fairly distinct individual was recognized by Dr. Hall as *Spirifer disjuncta*, a Chemung form."[4]

Near the summit of the path from the Mountain House to the Hotel Kaaterskill, over South Mountain, is a ledge of very coarse conglomerate, which is similar to the one in Twilight Park on Round Top. However, it is some 375 feet higher, considering the ledge in front of the Mountain House 2,225 feet A. T.[5] On the road toward the Hotel Kaaterskill, after the path enters it, is a small ledge composed in the center of a conglomerate layer, with gray sandstone above and below. Toward the hotel the conglomerate thickens rapidly, making an excellent locality for noting the rapid change in the thickness of a conglomerate. The strata on South Mountain are nearly horizontal, but in places there is very strong cross-bedding. Guyot clearly described the structure of the Catskill Mountains as follows: "We have not to look in the chains of the Catskill for a series of anticlinal and synclinal folds or arches, as in ordinary mountain chains. Throughout the region the strata of which they are composed are nearly horizontal from the bottom of the valleys to their top, or have a dip rarely exceeding 4° or 5°. The same is true of the plateaus."[6]

On the bank of the Kaaterskill Creek below Etna Cottage, east of

[1] Proc. Am. Assoc. Adv. Sci., Vol. XXIV, B, pp. 82, 83. For additional particulars see 28th An. Rep, N. Y. State Mus. Nat. Hist., pp. 14, 15.

[2] Geol. N. Y., Pt. I, p. 303.

[3] Am. Jour. Sci., 3d Ser., Vol. XLV, p. 205, section D of fig. 2.

[4] Op. cit., p. 207.

[5] Guyot, Am. Jour. Sci., 3d Ser., Vol. XIX, p. 449; and this conglomerate ledge is barometrically 150 feet higher.

[6] Ibid., p, 433.

Palenville, are red arenaceous shales (1497 A1), which contain the fucoid (?) markings of the Catskill red shales.

A short distance from this exposure, and to the north of the cottage and Drummond Falls House, in a branch of the Kaaterskill, are Drummond Falls. The cliff toward the house is composed of red shale, which breaks up into very fine fragments, with a little mottled shale in the lower part. The brink of the falls and upper part of the ledge to the north are composed of gray sandstone and shales. The foot of Drummond Falls is about 125 feet lower than the Palenville railroad station which makes its altitude approximately 389 feet A. T.[1]

No. 1497 B1—The Hugh Smith quarry is on the road from Saxon post-office to the great Falls of the Kaaterskill, and about one-half mile from them. The quarry is in the Hamilton "blue stone" belt, similar to the stone near West Hurley, and is composed principally of blue flagging stone with some shale stripping on top. The Great Falls of the Kaaterskill[2] (1497 B2) are below the covered bridge and post-office, about 4 miles east of Palenville. The brink of the falls is formed by a prominent sandstone stratum, between 3 and 4 feet in thickness, and at the bottom of the falls is another similar layer. Above the falls, in the coarse arenaceous part of the prominent sandstone stratum are fossil shells, such as are usually found in similar zones of the Hamilton. There is quite a decided dip between west and northwest.

FAUNA OF NO. 1497 B2.[3]

Spirifera mucronata (Con.) Bill	(a)
Spirifera granulifera Hall	(c)
Spirifera medialis Hall (?)	(r)
Strophodonta perplana (Con. (?)	(rr)
Grammysia bisulcata (Con.) Hall (?)	(rr)

Below the brink of the falls, and along the sides of the gorge are argillaceous blue shales (1497 B3), splitting up finely, which contain many fossils characteristic of the argillaceous Hamilton shales. The falls are about 40 feet in height.

FAUNA OF NO. 1497 B3.

Chonetes coronata (Con.) Hall	(c)
Spirifera mucronata (Con.) Bill	(rr)
Nyassa arguta Hall	(rr)
Nucula corbuliformis Hall	(rr)
Paracyclas lirata (Con.) Hall	(rr)
Nuculites oblongatus Con	(rr)
Loxonema delphicola Hall	(rr)
Lingula sp	(rr)

[1] Altitude of Palenville railroad station, according to a letter from C. A. Beach, superintendent Catskill Mountain Railroad, is 514 feet.

[2] This part of the creek is frequently spelled Cauterskill.

[3] Prof. William M. Davis reported at the Big Falls "*Spirifer accuminata* and *mucronata*, *Grammysia bisulcata*, and others" (Appalachia, Vol. III, June 1882, p. 29), and later said that "*Spirifer mucronata* and *medialis* are both of common occurrence" at this locality (Bull. Mus. Com. Zoöl., Geol. Ser., Vol. I, No. X, January, 1883, p. 318).

CONCLUSIONS.

This study of the Devonian system in eastern Pennsylvania and New York offers an opportunity to compare the different series of rocks composing the system in that region with those of the more typical sections in central and western New York. A comparatively small amount of investigation has latterly been given to the rocks of this system in eastern New York, while their continuation in eastern and central Pennsylvania has received much attention. On this account it seems better at present to discuss more particularly the conclusions of the Pennsylvania survey. In reference to the work of the Pennsylvania geological survey it is but just to state that the complicated geologic structure of the State has been worked out in an admirable manner and the stratigraphic position of the various formations accurately determined, so that the State has reason to be proud of its most excellent geological atlas. But with the exception of the fossil plants of the carboniferous, the paleontology of the State has never received the attention it deserves. This failure to give paleontology its due consideration is evident in the correlations of the local formations of the Paleozoic rocks of the State with the typical sections of these formations in New York. If the writer be able to correlate more accurately a part of the Devonian system of Pennsylvania with rocks of the same age in New York, he realizes that it is because he has had the advantage of a thorough field study of these formations at their classic localities, supplemented by careful laboratory study of their fossils. The study of the New York sections and fossils was under the guidance of Dr. Henry S. Williams, then at Cornell University, who has added so much to our accurate knowledge of the Devonian system of the United States, and to whom the writer is greatly indebted for methods and suggestions in working out this problem.

The Marcellus shale at the base of the Middle Devonian is generally clearly defined, except in the upper part, where it changes rather gradually from the argillaceous to the more arenaceous shales of the overlying Hamilton stage. The presence of fossils usually indicates the stage to which the shales belong, although in one or two localities species generally regarded as restricted to the Marcellus were found associated with those of the Hamilton. Prof. Lesley has called attention to this gradual transition from the black Marcellus to the overlying Hamilton shales, and says "it is evident that the distinction between *Marcellus* and *Hamilton* formations is a purely arbitrary one, the Marcellus deposits being continued into the *Hamilton* age; no reason but their darker color justifying their name; as the deposit became coarser its color growing lighter, chiefly, in all probability, because fine or mud clay has the faculty of absorbing and retaining petroleum better than coarser or more sandy clay."[1] Still there seems as good reason for retaining the Marcellus stage as that of many other

[1] Sum. Desc., Geol. Penn., Vol. II, f. n., pp. 1204, 1205.

formations, for it is very often the case that the transition from one formation to another will not be sharply defined lithologically in some part of its area.

The Hamilton stage as mapped and defined in Pennsylvania consists principally of rather coarse arenaceous shales and thin sandstones;[1] but to these deposits should be added the calcareo-arenaceous zone above, called Tully limestone, and the still higher, black, fossiliferous shales, called the Genesee. It has been shown in this paper that the so-called Tully and Genesee stages of Pennsylvania do not agree with the New York formations either in lithologic or paleontologic character. After the disappearance of the Tully limestone and Genesee black shale in central New York, there is very little evidence of the reappearance of either in eastern New York and Pennsylvania. Since this opinion is the reverse of that held by the Pennsylvania geologists, a brief review of the data offered in support of their correlation is in order.

Prof. White reports that "the top of the Hamilton is marked off everywhere in this district by the appearance of a dark, sandy fossil slate or shale, which seems to be identical with the Genesee black slate of the New York Reports. * * * It is also quite fossiliferous, containing *Spirifer mucronatus*, *Athyris spiriferoides*, *Microdon bellistriata*, *Tropidoleptus carinatus*, and many other forms."[2]

As might be inferred by one familiar with the Genesee outcrops of New York, the so-called Genesee of Pennsylvania does not closely resemble the typical Genesee shales in lithologic character, but, on the other hand, it conspicuously resembles the Moscow zone at the top of the Hamilton stage. As far as the paleontology is concerned, it has already been shown (p. 41) that these species are not characteristic of the Genesee, and in fact as far as my observation has extended they have never been found in undisputed Genesee shale, but are characteristic of the argillaceous shales in the Upper Hamilton. Furthermore, the difficulty of this correlation can not be removed by the supposition that the above fossils were incorrectly identified, for the writer

[1] Prof. Lesley, in his chapter on the "Hamilton sandstone and shale," proposes the following classification for the Hamilton of Pennsylvania:

Hamilton	Upper	*Moscow shales.*
		Encrinal limestone.
	Middle	*Ludlow sandstone.*
	Lower	*Skenecateles shale.*

In the explanation of this plan the professor says: "Why should not the original New York names, *Moscow*, *Skeneateles*, be revived? But if so, the original New York name for the middle division, viz. *Ludlowville*, would naturally accompany them or be adopted in the simpler form of *Ludlow*, especially as Prof. Hall justified its adoption by reference to its coincidence in time and fossils with the famous *Ludlow* formation of England."(Sum. Desc. Geol. Penn., Vol. II, p. 1237.) It is true that when Prof. Hall wrote his final report on the Fourth Geological District of New York in 1843 he compared the Ludlowville shales with the Ludlow rocks of England, but that was before the line separating the Devonian from the Upper Silurian had been determined with approximate precision, and such correlation was abandoned many years ago, for, as is well known, the Ludlow rocks of England form the upper group of the Upper Silurian, instead of belonging, with the Hamilton, to the Middle Devonian.

[2] G[6], pp. 107, 108.

has collected them in the same shales, in association with other characteristic Hamilton species.[1]

The Tully limestone horizon was described as follows by Prof. White: "A great coral bed is found directly under the Genesee shale at many localities in the district, corals, shells, and crinoids being often so abundant as to constitute it an impure limestone." The following species were reported: "*Zaphrentis Rafinesquii*, *Z. gigantea*, *Heliophyllum Halli*, together with several species of *Syringopora*, and other forms that I could not determine." Again: "There can be little doubt that this stratum represents the Tully limestone horizon of the New York Reports, and it thus becomes a valuable guide in correlating and classifying the rocks of the district."[2] It has already been pointed out that this zone does not lithologically resemble the Tully limestone of central New York, while none of the fossils mentioned by Prof. White are considered Tully species.[3]

In the prefatory letter to Prof. White's report of the following year, Prof. Lesley stated, "The presence of the Tully limestone, beneath the Genesee slates, in this part of Pennsylvania [central] is demonstrated."[4]

As far as reported by Prof. White, the evidence in favor of this demonstration is as follows: In the account of the Devonian rocks of this district, the Tully limestone is described in the section on Little Fishing Creek, Columbia County, as "a series of dull gray and bluish gray impure limestones, weathering with a buffish tint, and often presenting a slaty appearance; usually quite fossiliferous, the following species being frequently present: *Ambocœlia umbonata*, *Spirifera ziczac*, *S. fimbriata*, *Orthis vanuxemi*, *Atrypa reticularis*, *Chonetes setigerus*, *Phacops rana*, *Dalmanites calliteles*, *Platyceras*, sp ?, thickness 50 feet."[5]

Of the above list of fossils, five[6] of them occur in the Tully limestone of New York; but none of the characteristic Tully species were

[1] The above remarks in reference to the so-called Genesee of eastern Pennsylvania are not intended to apply to the horizon termed the Genesee group by Prof. Claypole in Perry County, in southern central Pennsylvania. The correlations of Prof. Claypole considered carefully the paleontology of the formations, and are the most accurate of the Pennsylvania survey. His description of the formation as "black, almost unfossiliferous shale," agrees more closely with the New York shales, and the *Styliola fissurella* Hall (F[2], p. 69), which he reports is a common Genesee fossil, although it occurs in the Marcellus, Hamilton, Portage, and Ithaca stages.

[2] G[6], pp. 109, 110.

[3] See list of Tully species by Dr. H. S. Williams, in Bull. Geol. Soc. Am., Vol. I, pp. 490, 491. Neither do they appear in the list of Tully fossils by Prof. S. G. Williams in Sixth Ann. Rept. State Geol. [New York], 1887, p. 26. This list included some species usually regarded as not belonging to the Tully limestone, and for comment on this point see Bull. Geol. Soc., Vol. I, pp. 496, 497, and f. n. on p. 496.

[4] G[7], p. VI.

[5] Ibid., p. 75. The specific identification of this list is supposed to be by Prof. Claypole, and on p. 289 the same species are reported as identified by Prof. Claypole, with the exception of *Orthis vanuxemi* and *Dalmanites calliteles*, from the section along the Susquehanna River between Catawissa and Bloomsburg ferry, Columbia County. The Fishing Creek section is again mentioned by Prof. White, who says, "The Tully limestone, No. 15, has the same ashen-gray cast with a tinge of buff on its weathered surface, and dark-blue color within, as everywhere else in the district. It is also fossiliferous here, and in it were seen *Phacops rana*, *Dalmanites calliteles*, *Ambocœlia umbonata*, and others not determined" (pp. 228, 229).

[6] *Ambocœlia umbonata*, *Spirifera fimbriata*, *Atrypa reticularis*, *Phacops rana*, and *Dalmanites calliteles*. (See list of important Tully species by Dr. H. S. Williams, in Bul. Geol. Soc. Am., Vol. I, p. 490).

reported, the above, as stated by Prof. White, being common Hamilton fossils.

In reference to the correlation of this horizon with the New York Tully, the professor said: "The Tully limestone is identified in this region only by its appearance; its fossils, as may be seen from the list above given [the one quoted above], are of the common Hamilton forms. It may be merely the upper portion of the Hamilton; but as the beds immediately above it are certainly the representatives of the New York Genesee, there can be no impropriety in referring the limestone to the Tully horizon."[1]

Recently Prof. White wrote me as follows: "With reference to the identification of the Tully limestone in G 7, it was entirely on the strength of the stratigraphic order, and not upon the fossils as then stated, so that it may well be a portion of the Hamilton."[2]

The exposures referred to the Tully limestone in central Pennsylvania have not been examined by the writer; but since they contain fossils that occur in the typical Tully limestone, are capped by shales which are nearly unfossiliferous (not by shales containing an abundant fauna of the Upper Hamilton, as in Monroe and Pike counties), it is possible that this horizon represents the Tully limestone of New York, and in this case, the horizon is not the same stratigraphically as the so-called Tully limestone of Monroe and Pike counties.

Prof. Lesley has considered particularly the Tully limestone in his final report, and it is important to review his opinion in reference to the Pennsylvania zone referred to this formation. He says: "In eastern New York, the Tully is wanting. From the Chenango River eastward a hundred miles, to the valley of the Hudson, at Catskill, no Tully limestone outcrop can be found between the Genesee and Hamilton formations; it was not deposited in this part of the sea; nor has it been seen in southern New York as far as the Delaware River; but its outcrop begins again in Pike county on the eastern point of Pennsylvania and extends westward to the Lehigh River, a distance of 60 miles."[3] A sketch map is given showing what is called the "Northern outcrop of the Tully" across central New York, and the "Southern outcrop of Tully limestone" across central and eastern Pennsylvania between the Susquehanna and Delaware Rivers.[4] It is further stated that between the north and the west branches of the Susquehanna River "the formation is at its thickest (60 feet), and its lithologic character the same as in New York. But, on the other hand, all its fossils are of Hamilton type, not a single peculiar New York Tully species having been as yet observed in it. On the Delaware it is nowhere more than 30 feet thick, retains its character, but holds no special Tully shells. The importance of these facts in their bearing upon our views of Paleozoic depo-

[1] Ibid., p. 76.
[2] Letter of Prof. White, January 19, 1892.
[3] Sum. Desc. Geol. Penn., Vol. II, p. 1313.
[4] Ibid., p. 1314.

sition can hardly be exaggerated. There is no mistake about the formation; it is everywhere the same kind of sediment, immediately succeeding the bluish sandy shale deposits of Hamilton age; immediately preceding the black mud deposits of Genesee age; laid down under the same conditions, filled generally with the same kind of animal remains, and apparently restricted to an area of great size indeed, but in reference to the whole Paleozoic water basin strictly local * * * while its two or three special or characteristic shells lived only in the northern part of its area."[1]

Finally, Prof. Lesley, commenting upon Prof. Claypole's general section of Perry County, in which 30 feet of very fossiliferous shales at the top of the Hamilton were not referred to the Tully limestone, says: "If then this zone does not represent the Tully, or Cuboides zone of Williams, what does it represent? I can not see that the absence of *Atrypa cuboides* (*Rhynchonella venustula*) from this perfectly well marked horizon on the Delaware, Susquehanna, and Juniata Rivers in Pennsylvania is of the slightest value, except to a paleontologist who cares little or nothing for rock sections. In fact, I can not but regard this as a flagrant instance of the superiority of stratigraphy over paleontology in any broad study of our formations."[2]

In the account of the different sections of this region, it has been shown that the lithologic character of the so-called Tully limestone of eastern Pennsylvania is not the same as the New York formation; its fossils are not Tully species, and it is not capped by the Genesee black shale; but on the other hand by argillaceous shales containing abundant fossils characteristic of the Upper Hamilton. If a correlation of this zone with one of central and western New York were attempted, I would suggest the encrinal limestone separating the fossiliferous, argillaceous Ludlowville and Moscow shales. As the Pennsylvania horizon may be represented by any one of the several coral horizons in the Hamilton of New York, or by an entirely different zone, such a correlation of this zone is very hazardous without careful comparison of the species and stratigraphy.

Finally, if any notice be taken of the evident bias against paleontology, it might be said that this furnishes an excellent example of the superiority of the combination of stratigraphy and paleontology over that of stratigraphy and lithology "in any broad study of our formations."

At first Prof. White regarded the Portage stage as unrepresented in eastern Pennsylvania, and said: "It was found impossible to identify any of the beds between the base of the Catskill and the top of the Hamilton with the Portage series of other portions of Pennsylvania, either on lithological or paleontological grounds, and hence I have applied the name Chemung to the entire interval, preferring to

[1] Loc. cit., p. 1315. [2] Ibid., p. 1322.

regard the Portage series as absent from this district. In this view of the matter I am influenced by several considerations, the chief of which are:

"First. The occurrence of characteristic Chemung fossils throughout the entire interval.

"Second. The total absence, so far as my observation has extended, of all the characteristic Portage fossils, not even a single Fucoid having been seen.

"Third. The Chemung character of the rocks considered lithologically, there being a total absence of those interstratified, hard, blue sandstones, which distinguish the Portage from the Chemung."[1]

While in the following report on central Pennsylvania is the statement, "I have found it impracticable to separate the Portage from the Chemung by any well-defined characters that would apply throughout the district; although it is very probable that 800 to 1,000 feet of the beds in the lower part of the group are the equivalents of the Portage beds in New York."[2] In a recent letter Prof. White states that he wishes the above statement to apply to Monroe and Pike Counties, and that the lower part of the formation called Chemung in those counties corresponds to the Portage of New York.[3] The professor says: "I would let the Chemung epoch end with the appearance of the first red bed, and confine the Portage to the basal, sparingly fossiliferous, flaggy beds, which I find 1,000 to 1,500 feet thick above what I have in Pennsylvania, termed the Genesee."[4]

Prof. Claypole described rocks containing *Cardiola speciosa* (now *Glyptocardia*) in Perry County, which are apparently quite similar to the portage of central and western New York;[5] while Prof. Lesley says, "On the Delaware River, in Pike, Monroe, and Carbon counties, as well as eastward toward the Hudson, and around the eastern and northern foot slope of the Catskill Mountains, in New York, the Portage formation can not be recognized as distinct from the overlying Chemung. In nearly 2,000 feet of strata from the Genesee black slate upward, no characteristic Portage fossil has been seen. Not a single seaweed has been found. All the shells are of Chemung type. There is a total absence of those hard, blue sandstones which distinguish the Portage in New York."[6]

From the preceding part of this paper we learn that the fossils of this formation are not characteristic Chemung species; but that they constitute a modified Hamilton fauna, similar to the faunas that occur

[1] G[6], 1882, p. 104.

[2] G[7], 1883, p. 68. In the descriptions of the section along the North Branch Railroad, near Rupert (p. 70), and the Fishing Creek (p. 228), in Columbia County, it is stated that Portage rocks may be present.

[3] Letter of February 22, 1892.

[4] Letter of January 19, 1892.

[5] F[2], 1885, p. 69.

[6] Sum. Desc. Geol. Penn., Vol. II, 1892, pp. 1364, 1365.

in central and eastern New York below the Oneonta sandstone, after the Tully limestone and Genesee shale have disappeared.

In reference to this correlation it is interesting to state that one of the New York geologists looked over the Spragueville collection, called it "high Hamilton" and said that it did not represent the Chemung at all. It might be added that collections from the so-called Tully, Genesee, and Chemung have been shown different New York geologists, not one of whom agrees with the correlation of the Pennsylvania survey.

The correlation of the "Chemung" of eastern Pennsylvania with the New York formation presents a more difficult problem than that of the "Genesee and Tully limestone," but I would call it Lower Portage. This subject has been considered quite fully in a recent paper, and some of the data in favor of such correlation may be found in that article.[1]

The Starucca sandstone was at first regarded as the base of the Catskill,[2] but in the following report it was considered as probably Upper Chemung.[3]

Finally, Prof. White writes: "My own opinion is that we should separate the Chemung and Catskill at the horizon of the lowest red beds, for these seem to come in at about the same general zone everywhere, and it is the only possible means of separation, for if we only rely upon fossils alone we can follow them up through the series until they leave us no Catskill at all, when we know absolutely we have 1,000 to 2,000 feet of them at these very localities."[4]

Any geologist who has followed this series of rocks from central New York eastward to the Catskills, and then along their eastern slope into Pennsylvania, knows very well that the red beds appear at different horizons in various parts of the area, and also realizes the utter impossibility of indicating the same approximate horizon by drawing a line through the lowest red beds.[5]

The Starucca sandstone is still left by Prof. Lesley as the base of the Catskill.[6]

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[1] Prosser, Am. Jour. Science, 3d ser., Vol. XLVI, pp. 212-230.

[2] Prof. White, G[6], p. 102, where it is stated: "In Wayne and Susquehanna counties the Catskill series is terminated below by a bed of greenish-gray sandy shales in which are often interstratified thin beds of sandstone which rarely become massive. From its occurrence near Starucca it was called the Starucca shale."

[3] The professor said, "it seems probable that the 600 feet of grayish-green beds at the top of the Chemung in Pike and Monroe, which in G[6] were referred to the Catskill, under the name of Starucca beds, may be the equivalent of a portion of the Upper Chemung of this district, and therefore erroneously referred to the Catskill in G[6] (G[7], p. 73).

[4] Letter of February 22, 1892.

[5] The most recent expression of this fact is by Mr. N. H. Darton, who says: "The lowest red beds have often been used as a criterion of discrimination between Chemung and Catskill, but they vary in stratigraphic position from the upper beds of the Hamilton, in eastern New York, to near the base of the Lower Carboniferous, in northwestern Pennsylvania, a difference in horizon of several thousand feet." (Am. Jour. Sci. 3d ser. Vol. XLV, p. 208).

[6] See Sum. Desc. Geol. Penn., Vol. II., 1892, pp. 1576, 1585, 1597.

The problem of the separation of the Chemung and Catskill was presented in an admirable manner by Prof. Stevenson, in his address before Section E of the American Association for the Advancement of Science, at its Washington meeting.[1] The Delaware River section was considered, and the professor proposed to draw the line separating the Chemung from the Catskill, between the Montrose red shale and the Montrose sandstone,[2] and he says, "A remarkable feature of the Chemung is the nonfossiliferous area of southeastern New York and the adjacent portion of Pennsylvania."[3] Furthermore, "The area in which the lifeless portion of the column reaches much below the horizon of the Lackawaxen conglomerate embraces parts of Carbon, Monroe, Pike, and Wayne Counties, of Pennsylvania, and Sullivan, Delaware, and Greene Counties, of New York, contains rather more than 4,000 square miles, while the whole area under consideration is more than 30,000 square miles. To explain the absence of life is not easy; it can not be due merely to an agent which caused the redness or greenness of the beds, for in Huntingdon and Fulton Counties, of Pennsylvania, the Montrose shales have many fossiliferous beds, though having also many green and red beds. Besides, the Delaware section shows a great thickness of beds of other colors, which are equally without animal remains."[4]

The writer did not find sufficient evidence to justify an attempt to indicate any sharp line between the Portage and Chemung and Chemung and Catskill stages of this region. In the Delaware flags *Orthonota* (?) *parvula* Hall was found, while still higher, near the transition from the Montrose shales to the Honesdale sandstones, *Spirifera mesastrialis* Hall and *Leda diversa* Hall (?) occur. The fossils seem to indicate that these rocks are not younger than the Lower Chemung; and in fact the geologist who has latterly given the Chemung-Catskill problem the most careful study remarked, on seeing the specimens, "This fauna is not as high as the Chemung, which would be characterized by *Spirifera disjuncta* Sow." It will be noticed that this interpretation of the section agrees more nearly with the correlation of Prof. Stevenson than with that indicated by the other Pennsylvania geologists for eastern Pennsylvania. It is probable that, beginning with the greenish shales and sandstones of the Starucca and the New Milford red shales, there is a series of deposits equivalent to the Oneonta sandstone of New York, which, as is well known, gradually passes into beds of typical Middle and Upper Portage in central New York.

The correlation of the Devonian system of eastern Pennsylvania, as indicated above, may be shown in the following table:

[1] "The Chemung and Catskill (Upper Devonian) on the eastern side of the Appalachian Basin," Proc. Am. Asso. Adv. Sci., vol. 40, 1892, p. 219. See an additional paper by Prof. Stevenson, in Am. Jour. Sci., 3d ser., Vol. XLVI, p. 330.

[2] Loc. cit., p. 227.

[3] Loc. cit., p. 240.

[4] Loc. cit., p. 241.

Table showing the geologic position and character of the formations composing the Devonian system of eastern Pennsylvania.

Lower Carboniferous.	Pocono.		Mount Pleasant conglomerate..	About 50 feet[1] in thickness.
Upper Devonian.	Catskill.		Mount Pleasant red shale.....	Red shale interstratified with greenish-gray sandstones; 300 feet in thickness.
			Elk Mountain sandstone and shales.	Greenish sandstones and shales; 200 feet (?).
			Cherry Ridge group	Red arenaceous shale at base with two massive conglomerate layers at top separated by shale; 325 feet (?).
			Honesdale sandstones	Somewhat pebbly sandstones, with some shaly, reddish sandstone.
	Chemung.	Portage (including Oneonta) and Chemung (of Prosser).	Montrose shales	Mainly red shale, but some greenish argillaceous shale. In upper part highest fossils, *Spirifera mesastrialis* Hall.
			Delaware flags.....	Greenish gray thin sandstones and shales with some red shale. *Orthonota (?) parvula* Hall in lower part; 1,200 feet.
			New Milford shale.....	Red shale; 100 feet.
			Starucca sandstone.....	Greenish gray massive sandstones; 600 feet.
			Chemung (of White) (*Paracyclas lirata* stage(?) of lower Portage, Prosser).	Olive and gray micaceous sandstones, with thin arenaceous shales, moderately fossiliferous; 1,150 feet (?).
Middle Devonian.	Hamilton.		Genesee shale. Tully limestone.	Wanting.
			Genesee shale (of White); Tully limestone (of White); Hamilton (of White).	Hamilton of Prosser.	The lower part consists of thin sandstones and arenaceous shales; next is a somewhat calcareous zone, and at the top argillaceous, fossiliferous shales; 1,400 feet.
			Marcellus shales.....	The lower shales are grayish, becoming very dark in the upper part; 800 feet (?).
Lower Devonian.	Corniferous.		Upper Helderberg (Corniferous limestone).	Cherty limestone; 200 feet.
			Cauda-galli grit	Sandstones and arenaceous slates; 250 feet.

2,000 feet.

[1] The thickness of the formations given in this table is in the main the same as that given by Prof. White in G[6] (see p. 76, etc.).

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