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No. 3

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H.S.W.

ON THE FOSSIL FAUNAS OF THE UPPER DEVONIAN ALONG THE MERIDIAN OF 76° 30′ FROM TOMPKINS COUNTY N. Y. TO BRADFORD COUNTY PA.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1884

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The publications of the United States Geological Survey are issued in accordance with the statute, approved March 3, 1879, which declares that—

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ANNUAL REPORTS.

From the above it will be seen that only the Annual Reports, which form parts of the reports of the Secretary of the Interior and are printed as executive documents, are available for gratuitous distribution. A number of these are furnished the Survey for its exchange list, but the bulk of them are supplied directly, through the document rooms of Congress, to members of the Senate and House. Except, therefore, in those cases in which an extra number is supplied to this Office by special resolution, application must be made to members of Congress for the Annual Reports, as for all other executive documents.

Of these Annuals there have been already published:

I. First Annual Report to the Hon. Carl Schurz, by Clarence King. Washington, 1880. 8°. 79 pp. 1 map.—A preliminary report describing plan of organization and publications.

II. Report of the Director of the United States Geological Survey for 1880–'81, by J. W. Powell. Washington, 1882. 8°. lv, 588 pp. 61 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881–'82, by J. W. Powell. Washington, 1883. 8°. xviii, 564 pp.. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882–'83, by J. W. Powell. Washington, 1884. 8°. xii, 473 pp. 85 pl. and maps.

MONOGRAPHS.

The Monographs of the Survey are printed for the Survey alone, and can be distributed by it only through a fair exchange for books needed in its library, or through the sale of those copies over and above the number needed for such exchange. They are not for gratuitous distribution.

So far as already determined upon, the list of these Monographs is as follows:

I. The Precious Metals, by Clarence King. In preparation.

II. Tertiary History of the Grand Cañon District, with atlas, by Capt. C. E. Dutton. Published.

III. Geology of the Comstock Lode and Washoe District, with atlas, by George F. Becker. Published.

IV. Comstock Mining and Miners, by Eliot Lord. In press.

V. Copper-bearing Rocks of Lake Superior, by Prof. R. D. Irving. In press.

VI. Older Mesozoic Flora of Virginia, by Prof. William M. Fontaine. In press.

VII. Silver-lead Deposits of Eureka, Nevada, by Joseph Story Curtis. In press.

VIII. Paleontology of Eureka District, Nevada, by Charles Doolittle Walcott. In press.

Geology and Mining Industry of Leadville, with atlas, by S. F. Emmons. In preparation.

Geology of the Eureka Mining District, Nevada, with atlas, by Arnold Hague. In preparation.

Coal in the United States, by Prof. R. Pumpelly. In preparation.

Iron of the United States, by Prof. R. Pumpelly. In preparation.

Lesser Metals and General Mining Resources, by Prof. R. Pumpelly. In preparation.

Lake Bonneville, by G. K. Gilbert. In preparation.

Dinocerata. A monograph on an extinct order of Ungulates, by Prof. O. C. Marsh. In press.

Sauropoda, by Prof. O. C. Marsh. In preparation.

Stegosauria, by Prof. O. C. Marsh. In preparation.

Of these Monographs, Nos. II and III are now published, viz:

II. Tertiary History of the Grand Cañon District, with atlas, by C. E. Dutton, Capt. U. S. A. 1882. 4°. 264 pp. 42 pl. and atlas of 26 double sheets folio. Price $10.12.

III. Geology of the Comstock Lode and Washoe District, with atlas, by George F. Becker. 1882. 4°. 422 pp. 7 pl. and atlas of 21 sheets folio. Price $11.

Nos. IV, V, VI, VII, and VIII are in press and will appear in quick succession. The others, to which numbers are not assigned, are in preparation.

BULLETINS.

The Bulletins of the Survey will contain such papers relating to the general purpose of its work as do not come properly under the heads of ANNUAL REPORTS or MONOGRAPHS.

Each of these Bulletins will contain but one paper, and be complete in itself. They will, however, be numbered in a continuous series, and will in time be united into volumes of convenient size. To facilitate this, each Bulletin will have two paginations, one proper to itself and another which belongs to it as part of the volume.

Of this series of Bulletins, Nos. 1, 2, and 3 are already published, viz:

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 40 pp. 2 pl. Price 10 cents.

2. Gold and Silver Conversion Tables, giving the coining value of Troy ounces of fine metal, &c., by Albert Williams, jr. 1883. 8°. ii, 8 pp. Price 5 cents.

3. On the Fossil Faunas of the Upper Devonian along the meridian of 76° 30′, from Tompkins Co., N. Y., to Bradford Co., Pa., by Henry S. Williams. 1884. 8°. 36 pp. Price 5 cents.

STATISTICAL PAPERS.

A fourth series of publications having special reference to the mineral resources of the United States is contemplated; of that series the first has been published, viz: Mineral Resources of the United States, by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

Correspondence relating to the publications of the Survey, and all remittances, which must be by postal note or money order, should be addressed to the

DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.

WASHINGTON, D. C., *May* 1, 1884.

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J. W. POWELL DIRECTOR

ON

THE FOSSIL FAUNAS

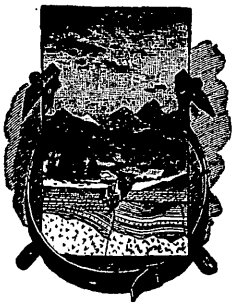
OF THE

UPPER DEVONIAN

ALONG THE MERIDIAN OF 76° 30′ FROM TOMPKINS COUNTY, N. Y., TO BRADFORD COUNTY, PA.

BY

HENRY S. WILLIAMS



WASHINGTON
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ON THE FOSSIL FAUNAS OF THE UPPER DEVONIAN.

By HENRY S. WILLIAMS.

The precise order with which geological faunas have made their appearance and succeeded one another is little enough understood for any long period of time, but for no period of geological history is there greater perplexity in regard to this order, in proportion to the knowledge we have of the species themselves, than for that filling the interval between the Upper Silurian and the Coal Measures of the Carboniferous.

This perplexity exists, not only for the American series, but in Great Britain—in Europe—wherever large areas have been geologically surveyed there are problems in regard to the relations of these faunas still unsolved.

In America the sections of the Devonian and the Sub-Carboniferous deposits are alike in no two States. In one section the changes in stratigraphical conditions are accompanied by well-marked faunas; in another, the species making up the faunas appear under different combinations, and species characteristic of distinct zones in one series will be found mingled in a common fauna of another.

That there is some explanation of these differences, some clew to this apparent confusion, is certainly to be presumed.

As the questions involved concern the laws of range and distribution of organisms, and thus are based upon the effects of changed or changing conditions of environment upon the organisms, we naturally look to the zoology of living forms for suggestions.

We find that in the present ocean the depth of water, the temperature, and the degree of saltness and the freedom from suspended impurities have all a marked influence upon the normal fauna of every part of the ocean.

Further, we find that on the two sides of the ocean—on opposite coasts of a continent—and even along a continuous coast-line, in two regions separated by a few degrees latitude, the faunas are characteristically different, and when these geographical areas are far separated, although under similar conditions otherwise, the faunas may contain scarcely a single species in common.

The revelations made by deep-sea dredging are also very suggestive. They have shown us that with all these differences in upper faunas, in the depths of the ocean species may range from one quarter of the

globe to the opposite quarter with scarcely a varietal modification, and when the physical conditions have been continuous, geological ages are not too long for the perpetuation of species without important modification.

Again, the wonderful effects upon the distribution of faunas produced by ocean currents is brought forcibly to our attention by the reports of our Fish Commission. Their investigations reveal the existence of an abundant fauna within a hundred miles of the New England coast, entirely distinct from the fauna prevailing all along that part of the coast out to deep water; and further, as Professor Verrill informs me, this unique fauna, which, at the time of its first discovery was composed of a large number of species and a great abundance of individuals, has now apparently left the region altogether.

From this we learn that in a very small geographical area we might find the remains of two entirely distinct faunas, preserved in two strata of a continuous formation, lying the one immediately upon the other, conformably, yet geologically entirely contemporaneous.

In the light of such facts the study of fossil faunas becomes an extremely complex problem.

The aggregation of species into faunas, the blending of one fauna with another, the rarity or abundance of particular species, variation in form or size or modification of specific characters, the extinction of old and the initiation of new forms—all these become the most delicate tests of change in the physical conditions, the record of which constitute the geological history of the earth.

For the correct solution of this problem the laws of geographical distribution form as important an element as geological sequence. The attempt to apply such principles to the study of the Devonian and Sub-Carboniferous deposits is no simple task, but the very fact that their faunas offer so great variation and difference in their combinations makes this series particularly attractive for the purpose.

In the eastern half of America are a dozen or so States in which more or less complete sections of the deposits, from the Niagara group to the Coal Measures, may be studied.

While our State surveys have been accurate and thorough for economical purposes, those engaged in the work have generally been satisfied with noting and describing the fossil species found in each geological formation, rarely are the complete faunas of any locality or stratum given in detail.

From our present literature it is difficult to ascertain anything beyond the general facts of the geographical distribution of fossil species; and the study of geological range is complicated by the uncertainties as to the precise equivalency of the deposits containing the fossils.

This study involves, therefore, not only an arduous review of the geological surveys of the several regions of the country, but requires

also a special preparation of long sections covering the whole series of deposits under consideration, and at such geographical intervals as will allow of the certain determination of stratigraphical equivalency between them.

In making such sections, it is important to note the exact order of the faunas and the abundance, rarity, difference in relative size, and any modification of form of the species contained in the fauna, together with the particular lithological character of the rock.

It was with such ideas in mind that I examined in the summer of 1882 a meridional section extending from Cayuga Lake southward to the first appearance of coal at the Barclay mine, in Southern Bradford County, Pennsylvania. This section, added to the well-known section exposed along the shores of Cayuga Lake, gives us a continuous series from the base of the Devonian to the coal lying above the first conglomerate of this meridian. I gave particular attention to the faunas marking the passage from the second Devonian Black Shale (the Genesee shale) through the "Portage," "Ithaca," and Chemung groups.

The precise thickness of the whole series must remain a matter of calculation. The numerous local sections were measured and may be put together, but the element of dip is not uniform, and can be reached only approximately.

The details of the stratigraphical characters constantly change, so that the sections of two ravines, within a few miles of each other, are quite different. Still, the general character of the rock masses and the prominent composition of the faunas are easily followed from one exposure to the next throughout the whole area examined.

The sequence of the faunas, which was particularly sought, was satisfactorily determined. I do not believe that the complete fauna of any particular zone has been given; but in the lists which follow all the characteristic species are undoubtedly included, and all the species thus far discovered in condition admitting of identification are also recorded.

It must be remembered that a great majority of the fossils of these Upper Devonian shales are in the condition of impressions, often very perfect, but many of them fragmentary. The section here examined lies between the third and fourth districts of the original State survey (see Vanuxem's Geol. of N. Y., 3d Dist., 1842, p. 170), and both Professor Hall, who reported on the fourth district, and Mr. Vanuxem, who reported on the third, regarded it as a typical section, though in no report are we able to find a satisfactory description of it.

The present condition of the rocks presents a series of gentle undulations, with a general slight dip to the south (see Proc. Am. Ass. Adv. Sc., Vol. XXXI., Pt. 2, p. 412); a continuation northward of the condition of things described in Report G, Second Geol. Surv. of Penn., p. 9, &c.

The average dip as estimated for this section is something over 25 feet per mile.

North of Ithaca, at Burdick's Glen, 4 miles from the southeast corner of Cayuga Lake, the Genesee shale appears capped by the sandstones and shales of the Portage group. At that point the top of the Genesee shale is about 60 feet above the lake level, or (376+60) approximately 440 feet above the sea level.

The fauna of this Black Shale contains, as was suggested by Professor Hall in his early study of these formations, several species of the fauna appearing in the Marcellus Black Shales which overlie the Corniferous limestone.

A comparative study of these and other faunas led me to infer that the Genesee fauna was merely a recurrence of the Marcellus fauna, a few species dropping out and a few being added, and that the same fauna did not become extinct with the incursion of sands and shales of the Portage group, but with some modifications continued to appear under favorable conditions after the Portage faunas were initiated. (See Recurrence of Faunas, Proc. Am. Ass. Adv. Sc., Vol. XXX, p. 186.) Evidence is also found of the recurrence of a partial Hamilton fauna just before the incursion of the fauna of the "Ithaca group" of Vanuxem.

These facts made it plain that over any particular area the faunas shifted back and forth with the advance of geological time. Hence I was led to the simple conception of a fauna as continuing on intact so long as the favorable conditions for its life continued, as shifting its habitat with the elevation or depression of the land with the advance or retrocession of the coast line. In such shifting and change of condition, one species after another may drop out and become extinct; others may suffer varietal modification, and, what is still more important, the sudden appearance of new forms may take place in the midst of the normal fauna—forms new to the locality only, or entirely new, so far as our knowledge of the fossils can tell us. Merely from the initiation of the new forms in the fauna we can gain no clew of its origin, but the study of its relations to allied forms of other faunas may enable us to decide whether it is a modification of some older form, or the forerunner of a new type, marking a later geological stage.

Thus our attention is called to the study of the typical forms of organisms with their variations—to associate their variable elements with locality or geological horizon, and thus to accumulate the elements for an historical account of organisms.

As we enter this field of investigation we soon find that specific names in palæontology have often been given under the influence of the belief in the old canon that each geological formation had its distinct set of organisms. Hence, when the boundary between two such divisions of the rocks is once established, the tendency has been strong to give separate specific names to representatives of the two formations,

and to define as specific the differences, which often prove to be little more than individual variations. It is therefore necessary to guard against deception caused by specific names.

In tracing the species of a single section backwards or forwards, we find at each stage a particular facies to the fauna, which suggests its nearest relation, and for this purpose varietal characters are especially valuable. For instance, in the Ithaca group the *Spirifera mesocostalis*, of the type "*prolata*" of Vanuxem or *D. acuminata* of Hall, is characteristic of the lower stage, while the higher, and particularly the Western New York variety, is Hall's typical *Sp. mesocostalis*. In the higher beds the two occur together, but the latter prevail; in the lower beds we never see the later variety. The varietal modification of the species then becomes a mark of the horizon. Many such cases might be mentioned, and the mere record of the species is not sufficient—the specimens should be examined in every case.

We have in the present section several clearly defined faunas of which I propose to give some account in this paper.

At the base of the Upper Devonian is the second appearance of the Devonian Black Shale. The limestone which underlies it is the Tully limestone. West of the Cincinnati axis there appears to be only a single mass of this Black Shale, and even in Ohio the separation of the Black Shales is not entire except in the eastern part, and there no limestone bed intervenes.

That these Black Shales were in some way associated with an elevation of the sea-bottom seems conclusive, from the relation they bear to limestone deposits below, and from the nature of the fauna and flora contained. Thus the Utica slates follow the Trenton limestone, the Marcellus the Corniferous limestone, the Genesee the Tully limestone, or where the Tully was wanting, the Hamilton itself is more or less calcareous.

The shales are mostly barren of marine fossils, and only rarely are distinct pieces of plant stems seen.

Lepidodendra and *Rhodea* are occasionally found.

The fauna is usually found near the top, and all the species are delicate and mostly minute or small.

The species detected in this locality are as follows:

FAUNA OF No. 34 D., GENESEE SHALE.

Discina lodensis.
truncata.
Lingula spatulata.
concentrica.
Styliola fissurella.
Tentaculites gracilistriatus.
Orthoceras subulatum.
Leiorhynchus quadricostatus.

Lunulacardium fragile.
Cardiola speciosa.
Ambocœlia umbonata.
Chonetes lepida.
Goniatites (a fragment).
Rhodea pinnata (stems).
Phthonia lirata.

The more abundant species are:

Discina lodensis.
Styliola fissurella.
Chonetes lepida.

The variety of *D. lodensis*, called by Hall *D. truncata*, is quite common. Comparison of numerous specimens leads me to believe that this is but a varietal modification of *D. lodensis.*

The rest of the species are rare.

Immediately above the Genesee shale are two thick sandstone layers separated by a few inches of shale, the whole about 4 feet thick.

In these sands and shales there are great numbers of pyrite nodules from the size of a pea, or smaller, to an inch and over in length. No fossils were observed in these first beds.

Following the sandstone are the sandy shales, characteristic of the Portage group.

Above the sandstone there occur some masses of black fissile shale resembling the Genesee shale, but neither so dark nor so soft. The silica predominates and the fauna is sparse, and, so far as observed, never bears the *Discina* or *Lingula* of the beds below.

Some lighter-colored, greenish, soft shales appear above, and in them occurs the first distinct Portage fauna.

The first species seen are Cardiidæ—the large forms, originally described as *Pinnopsis ornatum* and *P. acutirostra*—and on passing upward we soon meet *Cardiola speciosa*, *Goniatites*, *Hyolithes*, and *Coleolus*, and after passing fifty or a hundred feet of blue-gray, sandy shales, with some light olive argillaceous shale, and an occasional dark streak, the *Nuculas* and *Lunulacardium fragile* appear.

The passage is gradual from the lower to the upper of these subfaunas, and there is no distinct stratigraphical division of the series until we pass the brachiopod fauna, which is unique in holding *Spirifera lævis* in abundance. This fauna occurs about 200 feet above the base of the Portage formation in this meridian. About 50 feet below it, or say 150 feet above the Genesee shale, is a sparse but very interesting fauna, characterized by the abundance of a large *Cladochonus* (McCoy), a genus closely allied to *Aulopora*, of an undescribed species, which I have figured and described in MSS.

This is the first fauna which is distinct from the general Portage fauna with which it is interstratified. The fauna is that of Station No. 48 of my

records, and occurs in a dark, blue-gray shale, weathering brown, less arenaceous than the ordinary Portage shales, and outcropping along the side of Cayuga Lake Railroad, a little north of McKinney's Station.

FAUNA OF No. 48.

Cladochonus (McCoy), sp.
Spirifera subumbona, Hall.
Chonetes lepida.
Leiorhynchus mesocostalis.
Grammysia subarcuata.
Cardiola speciosa.
Goniatites complanatus ?
?*Leda curta.*
Palæoneilo filosa?
Nucula Randalli (or ? new).
Nuculites oblongatus.
Strophodonta mucronata.
Coleolus aciculum.
Orthoceras = a small form (= ? *O. bebryx*).
Arm of a small crinoid.
Stem of *Rhodea.*
A small Lamellibranch (= ? *Macrodon*).

This fauna (of Station No. 48), coming as it does entirely below the *Spirifera lævis* fauna, is remarkable as holding several species which are generally regarded as characteristic Chemung species.

The *Strophodonta mucronata* is particularly to be noted, but the entire facies of the fauna reminds us of the Ithaca group rather than anything below. The *Spirifera subumbona*, Hall, is well preserved, and exhibits the convex dorsal valve and the surface-markings of that species. That this is identical with the forms occurring in the higher Chemung faunas and called *Ambocœlia umbonata* var. *gregaria* of Hall, I have no doubt. It is also possible that the British and European *Spirifera urii*, Fleming, is specifically identical. This form is a characteristic of the Upper Devonian faunas, where it is generally associated with our representatives of "*Spirifera disjuncta* and *Orthis interlineata*," the species mentioned by Murchison as its common associates in the Barnstaple, Marwood, and Pilton series of North Devon. Its surface-markings, which are quite like those of *Spirifera lævis* (occurring just above it and but once elsewhere in the series for this meridian) lead us to associate it with the early representatives of the Carboniferous faunas.

Cladochonus is also, so far as recorded, a Carboniferous form. (See Murchison's Siluria, 2d ed., p. 299; Davidson's Brachiopoda, Pt. VI, p. 41; Hall, Geol. N. Y., 4th Dist., pp. 234, 261.)

The species collected from station 48, are all small and delicate, and some of them are mere fragments.

The *Cladochonus* and the *Spirifers* are the most abundant, and show the result of favorable conditions for growth.

The species, both below and above this stratum, are rare and generally fragile, and consist of pelagic forms, such as *Pteropods* and *Cephalopods* with a characteristic fauna of *Lamellibranchiates*, but scarcely a trace of *Brachiopods*.

The next distinct fauna we recognize is that of Stations No. 1 and No. 4, two points on opposite sides of the valley in which Ithaca is situated.

Station No. 1 is at the foot of Fall Creek on the east side, and No. 4 is at the southwest corner of Cayuga Lake. A few other exposures of the same horizon have been examined, but these two are characteristic.

The prominent species of this fauna are—

Spirifera lævis, Hall, and *Palæoneilo filosa*, Con.

Lunulacardium fragile is generally present but not abundant, and *Taxocrinus Ithacensis* is represented quite abundantly by fragments of the stem and by an occasional perfect head.

The other species named are representative of the fauna but are less frequently obtained.

In this list, as in others which follow, some species are recorded from fragmentary specimens from which only the generic characters can be determined with satisfaction.

FAUNA OF STATION No. I, B AND D.*

Spirifera lævis.
Palæoneilo filosa.
Lunulacardium fragile.
Chonetes lepida.
Taxocrinus Ithacensis.
Goniatites complanatus var. *perlatus.*
sinuosus.
discoideus.
Porcellia Nais.
Orthoceras pecator.
anguis.
Coleoprion sp.
Cardiola speciosa.
Styliola fissurella.
Hyolithes aclis.
Aviculopecten sp.
Cyrtina Hamiltonensis.
Grammysia subarcuata.
Modiomorpha subalata.
? *Aulopora* or *Cladochonus*, fragments.
Palæoneilo constricta.

* The species recorded in these lists are arranged in the order of their relative abundance at each station, the more common being placed first.

Cardiola transversa?
Leda perstriata.
Pleurotomaria sp.
Discina sp.
Leiorhynchus mesocostalis.
Crania sp.
"Lycopodites" Vanuxemi.
Leperditia.
Rhodea stems.
Fish bones, fragments.
Stictopora Meeki.

Some other species are recorded from the "Portage" at Ithaca, and may belong to this fauna, but the list here given includes only species known to belong to this particular horizon.

As far as known this fauna does not occur west of Seneca Lake, and, taken as a whole, it is characteristic of the eastern extension of the Portage group. I would call particular attention to the absence of *Prœcardium* (*Cardium?*) *vetusta* and *Cardiomorpha* (*"Unguļina"*) *subor-bicularis.* I have not observed either of these species in any part of the present meridional section, although they are frequently met with in the Portage formation a little farther west.

Three of the species will be remembered as common in the higher Chemung faunas (*Cyrtina Hamiltonensis*, *Grammysia subarcuata*, and *Modiomorpha subalata*), but they occur also below in the Hamilton group, or are represented by a closely allied form, as *Grammysia arcuata.*

Spirifera lœvis is a specially interesting form. It appears to be quite limited both in range and distribution. A closely allied form, *Sp. maia*, occurs in the lower Devonian of Ohio and Ontario, and a similar form appears in the Devonian of the far West. It is closely allied, if not identical, with *Spirifera glabra* of the British Carboniferous, and appears to link that species with the Devonian *Sp. curvata.* (See Davidson, Supl. Brit. Dev. Brachiopoda, p. 32.)

Tracing the faunas upward, after passing the *Spirifera lœvis* stage, the shales gradually loose their coarse bedded character, the laminæ become finer and more fissile, and about 30 feet higher up the rocks assume a decided fissile character—are composed of a dark, nearly black, shale, weathering reddish-brown from iron stain, and occasionally carry lenticular beds of very tough, siliceous sandstone. These sandstone masses I have described elsewhere as channel-fillings. (See Am. Jour. Sc., Vol. XXI, p. 318.)

The dark, fissile, argillaceous shales are generally about 20 feet thick; no fossils appear at their base, but toward the top are often found great numbers of *Lingulas* and a few other delicate species.

The famous Lycopodites beds of Professor Hall lie in these shales, where great numbers of *L. Vanuxemi* in very perfect condition occur, with stems of *Rhodea* and other plants, and large fish-bones.

Numerous exposures of this stage are seen in the ravines about Ithaca. My Station No. 6 gives a good exhibition of the fauna. In the following list the species named are from Station No. 6 and equivalent strata within a radius of a mile or so about it:

FAUNA OF STATION No. 6.

Lingula complanata.
Ptilophyton (Lycopodites) Vanuxemi.
Leiorhynchus mesocostalis and vars.
Lunulacardium fragile.
Cardiola speciosa (rare).
Lingula punctata.
spatulata var.
ligea.
Poteriocrinus, stems.
Productella, a minute species.
Styliola fissurella.
Rhodea stems.
? *Spirorbis.*
Rhachiopteris punctata.
? *Psilophyton.*
Productella truncata.
Palæoneilo filosa.
brevis.
Leptodesma sp.
Goniatites complanatus.
Microdon gregaria.
Orthoceras pecator.
Loxonema sp.
Rhynchonella eximia (young).
Pleurotomaria capillaria.
Phthonia lirata.

In this fauna *Lingula complanata* and *Lunulacardium fragile* are the characteristic species, and are generally abundant.

The *Ptilophyton* Dawson=*Lycopodites* is abundant in some localities, and the *Leiorhynchus* is also very abundant in some layers, but does not appear in all the exposures. The other species are rare; some of them are known only by fragments.

The *Leiorhynchus* is very variable, and is a thin, fragile shell in these shales, and often distorted.

Specimens occur which present more or less fully the distinctive characters of *L. limitaris*, of *L. quadricostata*, or of *L. mesocostalis.*

A comparative study of the specimens from various stages of the Devonian has led me to regard all the species of *Leiorhynchus*, of the New York Devonian at least, as varieties of a common form, whose plasticity has not permanently ceased at any of the horizons in which it

occurs. The different varieties appear to be closely related to the nature of the rock containing them; but, while the majority of individuals in any particular stratum are of one variety, in most every case some individuals present the characteristics of the other varieties.

Lingula complanata is of the type of the Ohio species, *L. membranacea* and *L. manni;* and the Brazilian species, *L. stauntoniana*, Rathbone, 1874, is indistinguishable from some specimens of *L. complanata*, and also occurs in a dark fissile shale.

This form is entirely distinct from the *L. ligea* and *L. ligea* var. of Hall, in so far as description and illustration go, but it appears to have been included among the typical specimens now in the American Museum.

A couple of specimens, agreeing entirely with the figures and descriptions of the *L. ligea* H, in the New York reports, have been found in these beds associated with the others; but the thin, almost perfectly flat character of *L. complanata* is characteristic of it, as seen in many hundred specimens. The theory that the latter is but a crushed *L. ligea* is contradicted by the observation that the flattening of an oval convex form, like *L. ligea* would increase the width near the center where the shell is most convex, while near the front the width would be little changed, so the sides would be even more curved, instead of being nearly straight as in the form called *L. complanata.*

As we pass above this soft shale, which is generally terminated by a 6 to 8 inch stratum of sandstone, the fauna changes.

A layer of concretions, like cobble-stones, occurs a few feet above the sandstone; this is followed by a thin stratum of arenaceous shale, with an abundance of *Lingula punctata.*

A few feet higher occurs my fauna No. 14 N—a remarkable recurrent Hamilton fauna, traces of which have been seen in several localities.

The species identified are as follows:

FAUNA OF STATION No. 14 N. Cascadilla creek 1102 A

= W&G 0. 1102 B N

Spirifera fimbriata.
angusta.
Pleurotomaria capillaria.
Ambocœlia umbonata.
Loxonema delphicola.
Leiorhynchus mesocostalis.
Rhynchonella contracta.
Orthoceras sp.
Avicula subdecussata.
Microdon tenuistriata?
Modiomorpha complanata.
Palœoneilo sp.
Lingula punctata.
L. sp.

The shales above Station No. 14 N become coarse and blocky, and so continue for hundreds of feet, interrupted by occasional thin beds of soft argillaceous shale and layers of hard sand.

The fauna characteristic of the "Ithaca group," of the early New York reports, begins to appear at this point, with *Leiorrhynchus* the first genus to be abundantly represented.

The form *L. mesocostalis* is more common in the soft shales, but in the more arenaceous beds the convex forms *L. globuliformis* and *L. Kelloggi* appear; but here, as in lower stages, the presence or absence of lateral plications, the number of folds on the sinus, or its prominence, and the general form of the shell are characters which vary in almost every handful of specimens, and lead us to believe that the representatives of the genus *Leiorhynchus*, found in the Devonian of New York at least, offer no better claim to specific distinction than do the various forms of *Atrypa reticularis*, although the variations of form and the relative prevalence of certain variations are valuable and, we believe, sensitive indicators of changed conditions of the environment.

There is a general rule which prevails among the forms called *Leiorhynchus*. In the early stages of the Devonian—the Marcellus shale or below—the majority of specimens are plicated over the sinus and way to the lateral margin of the shell, giving us typical *L. limitaris*, but even in the Marcellus, individuals, especially as they increase in size, drop the lateral plications. The prevailing type for the Hamilton is that called *L. multicosta*, in which the lateral plications are generally faint and fewer, while the central plications are strong and more raised than in the lower forms. In the Genesee, *L. quadricostata* is the common form, with the lateral folds nearly obliterated.

In the early Chemung, *L. mesocostalis*, *globuliformis*, and forms like *L. Kelloggi* prevail, while the small *L. sinuatus* is more common toward the top, all of them, typically, having smooth lateral slopes and a few plications along the center, forming a more or less distinct fold and sinus.

But we notice that a few specimens may be found in Chemung shales, plicated quite to the margin, as in the early type. Thus in interpreting the fauna of 14 N., the presence of the Chemung type of *Leiorhynchus*, although in the midst of a nearly pure Hamilton fauna, shows that, in time, we have passed the Hamilton stage, though Hamilton species are not yet extinct, and that we have a recurrent fauna, and not the normal Hamilton fauna. Thus the fossils independently confirm the facts which the stratigraphy testifies.

Passing this transition stage in which an occasional fossil appears—a *Palæoneilo*, a *Leiorhynchus*, or some other species of wide range—the fauna of the Ithaca group gradually makes its appearance. Between 150 and 200 feet above the *Lingula complanata* stage the Ithaca fauna appears in full force, and 50 feet higher has exhibited the full complement of its species.

The first species, which is thoroughly characteristic of the fauna, is

Spirifera mesocostalis of the eastern variety. This is the form figured in Pal. N. Y., Vol. IV, Plate 40, Figs. 1, 2, and 3. At the first appearance of this species, it is associated with *Leiorhynchus mesocostalis*, *Palæoneilo filosa*, and *Chonetes* of the *C. scitula* type, and traces of *Microdon* and of *Modiomorpha*.

This fauna may be seen at the base of the old inclined plane, my Station No. 27 A and B. = 1107.

A little higher *Rhynchonella eximia* appears, then *Orthis impressa* and *Strophodonta mucronata*, and these half dozen species, earliest to appear in the region, are characteristic and among the most abundant species of the fauna of this Ithaca group, viz, *Spirifera mesocostalis* (1st var.), *Palæoneilo filosa*, *Orthis impressa*, *Strophodonta mucronata*, *Leiorhynchus mesocostalis*, and *Rhynchonella eximia*.

Leiorhynchus is peculiar in being very abundant where it appears, but when it is abundant there are generally very few other species in the same stratum.

Having passed this first stage of the introduction of the fauna, we reach a sandstone bed, calcareous in some localities, forming a firestone bed, which is a consolidated mass of broken fossils.

The characteristic species of this layer are *Spirifera mesostrialis* and *Cryptonella eudora*.

In several places about Ithaca this stratum is worked for quarry stone. The old McCormick quarry of the early reports, the present University quarry, and several others, are at this horizon.

The University quarry, Station No. 5, is characteristic.

FAUNA OF STATIONS No. 5, ETC. 1105 A.

Spirifera mesostrialis.
Cryptonella eudora.
Spirifera mesocostalis 1st var.
Gomphoceras tumidum.
Cyrtina Hamiltonensis.
Orthoceras bebryx var. *Cayuga.*
Poteriocrinus Cornellianus.
Pleurotomaria capillaria.
Productella speciosa.
Euomphalus Hecale?
Grammysia elliptica.
Rhynchonella eximia.
Atrypa reticularis.
Ptilophyton (*Lycopodites*) *Vanuxemi.*
Rhodea (stems).
Fragments of wood.
Stictopora Meeki.
Microdon bellistriata.
gregaria.

Platyceras carinatum.
Modiomorpha concentrica?
Bellerophon sp.
Strophodonta perplana var. *nervosa.*
Rhynchonella Stephani.
Zaphrentis simplex?
Stromatopora sp.

To this fauna probably belongs *Streptorhynchus*, a single specimen of which I have seen from "Ithaca," but do not know the precise locality.

Below this zone, perhaps 50 feet, is found in a single locality, Station No. 37, a small but very abundant fauna of *Crinoids*, *Bryozoa*, and *Rhynchonella.*

FAUNA OF STATION No. 37. A USGS 1105B.

Rhynchonella eximia.
Poteriocrinus gregarius.
Stictopora Meeki.
Spirifera mesocostalis.
Cyrtina Hamiltonensis.
Productella, a small species.
Aviculopecten cancellatus.
Plates of a large *Arthroacantha.*
Two or three *Bryozoa*, undetermined.
A small *Lycopodites.*

The first three species constitute the mass of the fauna; the others are rare.

The lithological characters are interesting. In the midst of sandy shales containing the *Brachiopods* is included a stratum of but an inch or so in thickness of fine, soft, mud shale, almost black, and containing the *Crinoids* and the small *Lycopodites.*

The *Crinoids* are minute, but occur in great numbers and exhibit considerable variation. (See Proc. Acad. Nat. Sc. Phil. 1882, p. 22.)

Passing above Station No. 5 the typical Ithaca group fauna prevails for some hundred feet or more, then gradually lessens in the number of its species and individuals, and the last species to appear is the *Spirifera mesocostalis* and *Orthis impressa.*

The fauna is found in several of the ravines about Ithaca; the best exposures are in Fall Creek and the upper part of Cascadilla Creek, and along the cutting on South Hill called the "inclined plane" in the old State reports.

FAUNA OF STATIONS No. (10,) (27 C, D,) ETC. = 1107A
= USGS 1103A

The "Ithaca fauna" proper:
Spirifera mesocostalis 1st var.
Strophodonta mucronata.
perplana var. *nervosa.*
Cyrtina Hamiltonensis.

Productella speciosa.
Atrypa reticularis.
Microdon bellistriatus.
Leiorhynchus mesocostalis.
Orthis impressa.
Chonetes setigera.
Chonetes scitula.
Crania sp.
Productella speciosa, small var.
Lingula spatulata var.
Lunulacardium fragile.
Cytherodon quadrangularis.
Palæoneilo filosa.
Leda n. s.
Pterinopecten suborbicularis.
sp.
Leptodesma (several species).
Actinopteria Boydii.
Modiomorpha complanata.
Grammysia subarcuata.
Nucula sp.
Aulopora sp.
Orthoceras Bebryx.
fulgidum.
Bellerophon leda.
Pleurotomaria capillaria.
Tentaculites spiculus.
Stictopora Meeki.
Callopora, Hall, sp.
Platyceras sp.
Discina neglecta?
Goniatites uniangularis?
Orthoceras pecator.
Arthroacantha Ithacensis.
Productus dissimilis (abundant in a single locality).
Rhynchonella pugnus var. (frequent in localities).
? Strophodonta demissa.

This Ithaca fauna contains a few other species, but I have given the main list in approximately the order of their abundance. The species in the early part of the list are frequently seen, and some of them are abundant in localities; those recorded lower down in the list are rare, or seen, it may be, abundantly in single strata or localities. A few, not given in the list, are not certainly of this horizon, and are on this account omitted.

It will be noticed that a few of the species of the general Portage fauna are here included, as *Palæoneilo filosa*, *Lunulacardium fragile*, and

a few *Goniatites* and *Orthoceratites*, which occur here in imperfect condition, but *Cardiola speciosa*, a characteristic Portage form, has not been detected in the midst of the Ithaca fauna. 1168

However, a little farther south, at Station No. 68, Newfield, as the Ithaca fauna ceases, the typical Portage fauna reappears.

One hundred to one hundred and fifty feet above the termination of the Ithaca fauna, in dark, fine, argillaceous shales, appear the following species:

Cardiola speciosa.
Lunulacardium fragile.
Lingula complanata.
Bellerophon mœra.
A small *Palœoneilo.*
Rhodea stems.
Strophodonta mucronata.

This is the fauna of No. 68 A and B. 1168

This I take to be the mark of the final withdrawal of the Ithaca fauna from this geographical area, and the return of the general Portage fauna.

What is also remarkable of this fauna in this region is its withdrawal in the reverse order in which it came in.

After the Brachiopod fauna is pretty well gone, there appears a soft, almost black, argillaceous shale bearing *Discinas*, and above this, and almost alone, occurs *Spirifera lœvis*, which, it will be remembered, appeared in abundance entirely below the Ithaca fauna, and was in the zone preceding that in which the *Lingula complanata* fauna occurred.

This Ithaca fauna does not appear far west of Ithaca, but a few of its species—the Cladochonus subfauna almost entire—appear 20 miles west in ravines running into Seneca Lake.

It will be noticed that *Strophodonta mucronata* also appeared in Station No. 48, the earliest forerunner of the Ithaca fauna. 1113 b

The study of the order of the faunas alone in this meridian furnishes strong evidence for the opinion that what I have called the Ithaca fauna, which was characteristic of the "Ithaca group" of the early State geologists, is geographically a temporary fauna, preceded and followed by the conditions and fauna generally regarded as belonging to the Portage group. This subject will be further discussed when the sections in other parts of the State shall be brought under consideration.

In this meridian several hundred feet of deposits follow, in which almost no fossils occur. Its general character is that of coarse arenaceous shales with thin seams of sandstone, tending, in the upper part, to flaggy and uneven, wave-marked strata. Interstratified with these are thin streaks of greenish argillaceous shales, in which are seen, rarely, the species of the Portage fauna.

This condition of things prevails, at this meridional section, until

about 1,300 feet above the top of the Genesee shale, where the first of the typical Chemung faunas appear.

The first species of this fauna, that I have detected, are on the high hill south of Ithaca, in Danby (Station No. 58), about 1,500 feet above the sea, and estimated to be stratigraphically 1,300 feet or more above the Genesee shale.

A lithological difference is clearly seen in the change from dark, tough, wave-marked, arenaceous shales with interstratified greenish argillaceous shales, to soft, coarse-bedded, blocky shales, weathering brown and rapidly disintegrating into rich yellow soil. The first species met with were from Station No. 58:

Productella lachrymosa.
Ambocœlia umbonata var. *gregaria.*
Orthis impressa (second variety, wide and large).
Atrypa reticularis.
And a few other imperfect fossils.

Both east and west of this locality, in Caroline and in Newfield, are hills rising to 1,800 or 1,900 feet, and the upper part of these hills, though mainly covered by a deep coating of soil, exhibit outcrops and loose slabs and blocks, still angular (thus evidently not transported), in which the Chemung fauna appears.

Still farther south the same rocks and fauna are found, in place, at a lower level.

Numerous sections have been made along this meridian, containing the Chemung fauna. It is an abundant fauna, and it appears to have been subdivided into a few local subfaunas. Still it is difficult to speak positively here, on account of the rapid change in the detailed stratigraphical conditions. Sometimes it is difficult to trace some particular fossiliferous stratum even across a wide gorge of a few hundred feet. However, I have been able to determine the order of the subfaunas of the Chemung group as follows:

As before mentioned, traces of the fauna occur before it appears in full force, and as in the case of the Ithaca fauna, the forerunners of the Chemung fauna are characteristic species and also species of wide geological range. There are such species as *Productella lachrymosa*, *Ambocœlia umbonata* var. *gregaria*, and the wide form of *Orthis impressa*.[1]

After these species had appeared, and far above the last traces of the Ithaca fauna, a stage of fine, fissile, argillaceous shales, in some exposures nearly black in color, appeared at the base of the series of strata bearing the main Chemung fauna. This dark shale is well represented at Van Ettenville, my Station No. 62 A. It appears also at the bottom of the cliff at lower Chemung Narrows, Station No. 67 A. In the midst of the

[1] In giving the names of species in this paper I have intentionally chosen those names by which the forms are more commonly designated in collections of New York fossils; points of nomenclature and comparison of local varieties with each other, and their identification with species of wider or distant geographical areas, may appropriately be left for special consideration.

shale are generally found flattened concretions of brown hematite, often inclosing a few species which are more abundant in the beds higher up. This is, so far as I know, the lowest Devonian horizon for definite agglomerations of the hematite ore.

The shales themselves carry a Lingula fauna, very similar to that in the dark shale at the base of the Ithaca group, but mingled with other species. These latter species appear to belong normally to the fauna of the common Chemung shales with which the Lingula-bearing shales are interstratified.

The following species occur in the fauna of Station No. 62 A and B:

Lingula complanata.
punctata.
Spirifera mesocostalis (2d var.).
mesostrialis (2d var.).
Ambocœlia umbonata var. *gregaria.*
Cyrtina Hamiltonensis.
Orthis impressa (2d var.).
Atrypa reticularis.
Leptodesma sp.
Chonetes scitula.
Crinoid stems (?= *Taxocrinus*).

A variety of *Lingula spatulata* occurs in similar shales of Station No. 67.

The following species appear in a similar shale at about the same horizon, and I believe them to belong to the same subfauna:

Productella speciosa (small var.)
Rhodea stems.
Palæoneilo filosa.
Schizodus sp.
Euomphalus Hecale?

This subfauna and the containing shales gradually pass up into coarser, brown, arenaceous shales and the normal Chemung fauna.

The most northern exposure, at which the typical Chemung fauna was found in abundance, was high up in the hills in the northeastern part of Chemung County, near Park Station of the Utica, Ithaca and Elmira Railroad, between 1,400 and 1,500 feet above the sea. It is my Station No. 72, with the following fauna:

Orthis Tioga.
carinata.
Strophodonta cayuta.
Productella lachrymosa.
Spirifera disjuncta.
Atrypa reticularis, vars. *spinosa* and *hystrix.*
Spirifera mesostrialis (2d var.).
Ambocœlia umbonata var. *gregaria.*

Spirifera mesocostalis (2d var.).
Streptorhynchus Chemungensis.
Pterinea Chemungensis (Con.).

The above are the more common species at this locality, and in every locality in this region where the Chemung fauna appears in full force. With the above are associated a long list of other species, met with more rarely in any particular locality and less universally, but in several cases locally abundant.

The cliffs along the narrows, above and below Chemung village, contain the typical Chemung fauna.

I have added some species to those already quoted from this locality by the State geologists and others. 1165 1166 1167

TYPICAL CHEMUNG FAUNA (STATIONS NOS. 65, 66, AND 67).

Orthis Tioga.
Streptorhynchus Chemungensis.
Aviculopecten pecteniformis Hall.
(= *Pterinea Chemungensis* (Con.)) H. S. W.
Strophodonta Cayuta.
demissa.
Productella lachrymosa var. *lima.*
costatula.
Spirifera disjuncta.
Ambocœlia umbonata var. *gregaria.*
Atrypa reticularis.
Rhynchonella contracta.
Leiorhynchus sinuatus.
mesocostalis.
Cryptonella eudora.
Pteronites spinigerus Con.
Pterinea protexta Con.
Avicula multilineata Con.
Cypricardites (*Goniophora*) *Chemungensis.*
Schizodus (*Nuculites*) *Chemungensis* (Con.).
Grammysia subarcuata H. & Whit.

The rarer associates of this fauna are:

Chonetes setigera.
Illinoisensis ?
Pleurotomaria capillaria.
Euomphalus sp.
Callonema sp.
Rhynchonella sappho.
Orthis michelini L'Ev. (if distinct from *O. Vanuxemi*).
Glyptodesma sp.
Bellerophon mœra.

Platyceras sp.
Cyclonema sp.
Orthis leonensis.
Knorria, a fragment.
Cladochonus sp.
Orthis carinata (abundant).
Strophodonta perplana var. *nervosa.*
Taxocrinus Ithacensis.
Gomphoceras, a fragment.
"*Fucoides graphica.*"
Spirifera fimbriata (a single specimen in Station No. 60).
Spirifera mesocostalis (2d var.).
Atrypa aspera.
Orthis impressa (wide var.).
Rhynchonella orbicularis.
Discina grandis.
Mytilarca Chemungensis.

A little farther east the following species occur in the same general association:

Tropidoleptus carinatus.
Microdon bellistriatus.
Crinoid stems.
Spirifera mesostrialis (3d var.).
Phacops rana.
Dalmanites calliteles ? (a trace).
Cyrtina Hamiltonensis.
Palæoneilo bisulcata.
Loxonema styliola.
Productella speciosa.

Two zones in the formation, in the midst of the general fauna and a calcareo-arenaceous rock (Nos. 67 E and H), carry the following additional species:

Zaphrentis, sp.
Heliophyllum, near *H. Halli.*
Stomatopora, sp.
Stictopora, sp.
Tentaculites spiculus ?
Crinoid stems and some other *Bryozoa* not described.

These corals, occurring as they do mainly in the condition of casts, are of little satisfaction except as marking the presence of the genera.

Prof. James Hall early recognized the "Cyathophylloid" corals in the Chemung fauna, but, so far as I know, the species are not described, nor are any species recorded from the Chemung group of New York. (Geology N. Y., Part 4, p. 255.)

A study of this typical Chemung fauna, as exhibited a few miles

each side the Chemung-Tioga County line, reveals the following general laws as to its conditions, characteristic species, and relations to other faunas.

The fauna prevails through about 250 feet of strata. The general character of these rocks is a series of alternating shales and sands, the argillaceous ingredients generally prevailing over the arenaceous, strongly ferrous, expressed rarely in the presence of ironstone concretionary nodules, but commonly recognized only by the universal iron-stain these rocks show upon weathering, and the rich, brownish-yellow color of the soil produced by their disintegration.

Near the beginning of the fauna, the shales tend to assume a fissile character, associated with the presence of the Lingula subfauna before mentioned.

As the fauna has reached its maximum development, a calcareo-arenaceous deposit appears carrying a rich coral and bryozoal subfauna, which reappears again toward the close of its prevalence in this area, each time marked by the continuance, for longer than usual, of undisturbed conditions favorable to the deposit of thick, solid sandstone strata. These sandstones must have been relatively local, as they vary both in thickness and in the character of the deposit, when followed along for even a few hundred feet of continuous exposure.

The Chemung fauna is recognized for a thickness of full 300 feet of strata, and the coral sandstone occurs three times in the series at Lower Chemung Narrows, and was recognized twice at the Upper Narrows. Since this sandstone is calcareous, and is marked by the presence of Cyathophylloid corals and Bryozoa, associated with the Chemung Brachiopod fauna, it becomes an important stratum in the comparison of separate sections.

In the several localities measured, the first and third coral sandstones are separated by about 250 feet of strata.

The second sandstone is in Station No. 67, about 15 feet above the first.

These sands vary considerably in thickness, and when a cliff of a few hundred yards is exposed, the corals may be abundant at one end of the cliff and no trace of them at the other, the sandstone seam itself also breaking up into alternating thin layers of shale and sandstone, and losing in great measure the calcareous character. For these reasons I have given average measurements.

There appear to have been two stages in the series in which this coral subfauna was locally abundant, and they were probably confined to limited areas in the form of shallow basins. They were separated by an average of 225 feet of shales, the majority of which was comparatively barren, but with the second incoming of the coral sandstone the principal Chemung Brachiopods returned, though not so abundantly as at first.

In some localities these sandstones are thick-bedded and form consid-

erable quarries of fair building stone. As far as determined, the highest sandstone was the more fully developed and contains the thicker bedded sandstone. Though it is possible that in some area the first two sands may have been continuous, forming 15 or 20 feet of sandstone.

Above the horizon of this upper sandstone no good exposures of the strata were found on this meridian until passing the State line and reaching Ulster, Bradford County, Pennsylvania.

In the cuttings made through the rocks by Cash Creek, exposures of Upper Chemung strata were examined. Here at my Station No. 81 a sparse fauna was obtained in a thin, semicalcareous, coarse sandstone containing considerable amount of large fragments of fossil wood and fish bones, with occasionally small pebbles. In Bradford County, Pennsylvania, the folds of the rock masses have become quite marked, as was reported by Mr. Sherwood in the Pennsylvania report, second survey, Report G.

The exposure at Cash Creek is at about the same altitude as that at Chemung Narrows, but is situated near the axis of the Blossburg Mountain Synclinal of Sherwood's Report G, p. 44.

The relation of the strata to those exposed at Chemung Narrows is a matter of calculation, and though they are certainly higher, stratigraphically, than the latter I feel no confidence in exact figures given to express the relative position.

Examination of the series farther west in the same county leads me to believe that the Ulster beds are situated within 300 feet above the upper coral sandstone of Chemung County, New York, and that there is no abundant Chemung fauna between. Further investigations may disprove this opinion, but I think it is very doubtful if the few traces of Chemung species found further south are any higher in the series than these Ulster beds.

The fauna of Station No. 81 C is as follows:

Spirifera mesocostalis.
Ambocœlia umbonata var. *gregaria.*
Strophodonta Cayuta.
perplana? var. *nervosa?*
Streptorhynchus Chemungensis.
Chonetes sp.
Spirifera, like sp. *Carteri*, but having some features similar to *Syringothyris*, and too imperfect to determine with certainty.
Crinoid stem, ¼ inch in diameter, and resembling those of Sub-Carboniferous species.
A small *Rhynchonella.*
Fragments of fish-bones.
Fragments of wood.
A few small pebbles were also seen.

This is plainly an Upper Chemung fauna. It exhibits also traces of

nearness to the conglomerate and the conditions characterizing the Catskill group.

In regard to the position in the series to which the fossiliferous beds in Franklin Township should be referred, I am in doubt. (See 2d Geol. Surv. Penn., G, p. 37.) The relation which the beds may bear to the red "Catskill" rocks above does not help the matter, since it is pretty well proven that these red rocks began to intrude themselves into the marine deposits at quite different stages in the series of different localities.

Up to the decline of the typical Chemung fauna my investigations along this meridian gave me reasonable satisfaction; but with the approach and intrusion of the coarse reds and grays the faunas were much confused and broken up. It is probable that except for local areas the majority of the fauna was destroyed.

In order to a clear understanding of the final history of these marine Devonian faunas, it will be necessary to study them in some area where these red beds (which, like the old reds of Great Britain, were probably deposited in fresh or brackish water) do not interrupt the continuity.

The elevation of land, which was evidently taking place over this area at this time, produced in some cases shore conditions where conglomerates were deposited, and in others great land-locked basins, from which, with the total or partial exclusion of salt water, the marine fauna rapidly perished.

Wherever the shores, produced by the elevation, were mere extensions of mainland with rocky exposure, we may suppose that beds of conglomerate might result; but where the land was produced by bringing the bottoms at a distance from land up to the surface, we may suppose that the nature of the deposits would not be greatly changed, except in so far as the shutting off the direct action of the sea would affect them chemically.

So long as the Chemung fauna found congenial conditions of life outside, it is reasonable to infer that its species might occasionally be intruded into these basins and thus appear interstratified with red rocks. That there was such lifting of the marine bottom to the surface, in regions where the red rocks precede conglomerate or coal, is shown by the irregular bedding and channeling of the beds, with very little change in textural qualities of the deposits which preceded the red "Catskill" deposits. Where the Chemung conditions follow up to the conglomerates, as in Western New York, this irregular bedding does not occur till the shore conditions of the conglomerate were actually present.

The present section alone does not give us the data for determining the order of the faunas in this upper part of the Devonian series.

I hope at some future time to be able to clear up this point by applying to it the results of study upon other sections.

After leaving the last fauna at Ulster, I estimate that there are ap-

proximately 1,000 feet of coarse reds and grays and conglomerates before reaching the Barclay coal, which lies some 2,000 feet above the sea. (2038. 2d Geol. Surv. Penn., G., p. 13.)

The "Ithaca group" was regarded by Mr. Vanuxem, the geologist of the third district, in 1842, as one of the primary subdivisions of the Erie division. (See Geol. N. Y., 3d Dist., p. 174.)

In 1841 Professor Hall expressed the opinion that the separation of this from the typical Chemung group was not supported by comparison of the fossils; and in 1843, in the report of the fourth district, he discarded the Ithaca group, regarding it as identical with the Chemung group, as represented along the Chemung River. (See Geol. N. Y., 4th Dist., p. 250.) The reason given was "the impossibility of identifying them as distinct by any characteristic fossils." This opinion has prevailed ever since.

Although the faunas are very similar, there can be no doubt that along the present meridian they represent two distinct geological stages. That they blended in some measure further east may be possible, in the same way that it is probable that on going westward the Marcellus and Genesee stages blended.

Although I do not doubt that the Ithaca fauna is an early stage of the Chemung fauna, I am persuaded that the two may be readily distinguished by their fossils.

That the typical Chemung fauna is thus distinct from that of the Ithaca group and characteristic of a later stage, is shown, palæontologically, by the following considerations:

The genera *Spirifera*, *Orthis*, *Strophodonta*, and *Productella* are common to both faunas, and are represented by numerous individuals at almost any fossiliferous exposures of either group. But for each genus the species are different. *Spirifera* is represented in the Ithaca group by *Sp. mesocostalis* var. *acuminata* and the first variety of *Sp. mesostrialis*.

The Chemung group is characterized by *Sp. disjuncta*, *Sp. mesocostalis* 2d var., a large, coarsely plicated, broad form, and *Sp. mesostrialis* 2d var., the wide mucronate form, neither of which is seen in the Ithaca group.

Orthis, in the Ithaca group, is *O. impressa* of the narrow variety, rarely wider than long.

In the Chemung group *O. impressa* is the 2d var.; wide form, with broad sinus; also there are *O tioga* and *O. carinata*, neither of which is known in the Ithaca group.

The *Strophodontas* of the Ithaca group are *Str. mucronata*, and the closely allied variety of *Str. perplana* var. *nervosa*.

In the Chemung group *Str. cayuta* is the prevailing form, and a coarser, more irregular form of *Str. perplana* var. *nervosa*.

Str. demissa is reported from both groups, but is extremely rare in either.

Productella is represented in the Ithaca group by *P. speciosa*, and a

small form I have identified as *P. speciosa*, small variety. In the Chemung it is *P. lachrymosa* and *P. costatula.*

Besides these genera, *Streptorhynchus* is common in the Chemung group, and it is extremely rare, if it appear at all, in the Ithaca group.

Ambocœlia umbonata var. *gregaria* is abundant in some stages of the Chemung group, but is rarely ever seen at Ithaca. The latter two forms are seen below the Ithaca group, hence their absence there is evidence of modified fauna, rather than extinction.

These differences in the prevailing varietal, or specific characters of common genera, which (as genera) are known to be common for a considerable range below and above the stages under consideration, I take to be more reliable evidence of actual difference in horizon than would be any number of distinct species of different genera in the two faunas.

SUMMARY.

The following is a summary of the order and general relative position of the faunas from the Genesee slate to the Barclay coal, which my present knowledge leads me to believe is true for the meridian passing through Ithaca, N. Y., running southward.

1st. Genesee slate fauna.

2d. Portage group fauna, distributed through approximately 1,300 feet of strata, but interrupted by the intrusion of the Ithaca fauna and several sub-faunas.

3d. Chemung fauna, occupying at least 1,200 feet of strata, with perhaps two sub-faunas, and driven out or destroyed by the presence of the conditions marked by the deposit of red and gray Catskill rocks.

Within the limits, assigned to the Portage group in the western part of New York State, I believe should be included for this meridian all those deposits lying between the Genesee shale and the lowest yellow-brown shale and sandstones which carry the true Chemung group fauna.

This series, as a whole, may be described as arenaceous, dark-colored shales with the *Cardiola speciosa* fauna, toward the top running into wave-marked, tough, arenaceous deposits, almost totally barren, so far as known.

The passage, between this series and the true Chemung, is stratigraphically indistinct, but in a general way it may be recognized by the clearer separation of the argillaceous from the arenaceous deposits after passing the line, and the appearance of lighter-colored sandstones in the midst of softer argillaceous shales, in which iron nodules and iron stains become more conspicuous than below.

The shales of the Portage below are thinner and of more greenish tint, and its sandstones are darker in color and thin, tough, and wave-marked or flaggy. Palœontologically, however, the transition is more marked.

The upper part of the Portage appears to be utterly barren except

in an occasional thin stratum of green shale, a *Cardiola speciosa*, or a small *Palæoneilo*, or *Leda* may appear.

As soon, however, as we reach the true Chemung rocks we meet large *Productella lachrymosa*, *Ambocœlias*, and *Spirifers* of the Chemung types. Within the limits of the Portage group, as so defined, we find in this area several secondary faunas intruding, but with limited geographical distribution, some of which we are able to trace toward, if not to, their origin.

The first of these is the *Cladochonus* fauna of Station No. 48, an outlier and forerunner of the Ithaca fauna, and entering this area from the east and traced as far west as Seneca Lake.

The second is the *Spirifera lævis* fauna, also coming in from the east, and not known west of Cayuga Lake Valley.

The third is the *Lingula* fauna of the Ithaca shale, which I think may be connected with the general black shale fauna, and if so, it was intruded from the west.

Fourth, is the thin recurrent Hamilton fauna, which may have been some little colony that had escaped destruction, or remained after the general retreat of the Hamilton fauna.

It is not improbable that evidence will be found proving conclusively that, after the general prevalence of the Portage group and its fauna, the Hamilton conditions and more or less of its fauna may have continued to live in some region east and north of this area.

Fifth, was the general Ithaca fauna, with a single coral, sub-fauna, in its midst found in the one heavy bedded sandstone of that group. This sandstone is semi-calcareous where the coral occurs, and in places it is a mass of comminuted, broken shells. In this sub-fauna, also occurs the Terebratuloid fossil *Cryptonella Eudora*.

The Ithaca fauna was substantially a Brachiopod fauna, with the characteristic forms *Spirifera mesocostalis*, *Orthis impressa*, *Strophodonta mucronata*, and *Cyrtina Hamiltonensis*, and others.

This fauna is the regular successor of the Hamilton fauna, and is intermediate between it and that of the Chemung group. It appears to have come in from the east. It prevailed during the deposition of two to three hundred feet of arenaceous shales; the coral sandstone fauna came in before its maximum development. At the close of its occupation of this area a dark, fissile shale with a *Discina* fauna came in. This I believe to be another outlier of the Genesee shale conditions, whose center at this time must have been toward the western part of the State.

A few feet above this dark shale the representatives of the *Spirifera lævis* fauna reappeared, among them a well-developed specimen of *Spirifera lævis*. Above this point the rocks are relatively barren except for the occasional presence of a small specimen of *Productella* or *Spirifera*, or traces of the Portage fauna, until the incoming of the Chemung fauna, three or four hundred feet higher up.

The Chemung fauna came in gradually, and before it was thoroughly

introduced, there appeared a dark, fissile shale very similar to that underlying the Ithaca fauna. This dark shale carried a Lingula fauna, the principal species of which were the same as those in the Ithaca dark shale, but the associated forms are of the upper Chemung types, showing it to be a recurrence at a later stage, and not identical with the Ithaca-Lingula fauna, as the stratigraphical evidence also clearly indicates.

Not long after the Chemung fauna had fully occupied the area, a massive, often calcareous sandstone was deposited, containing an interesting coral sub-fauna. Again, some 250 feet higher up in the series, and near the close of the dominance of the Chemung species, the coral subfauna reappears under like conditions.

Above this zone Chemung species are rare, but are the only marine forms to appear at all till after the deposit of the red sands and conglomerates.

Toward the close of the Chemung period there were disturbances over this area which made it impossible, with the present knowledge of the series, to define the passage of the Chemung fauna into anything higher up.

Even after traces of the red "Catskill" rocks were deposited, some of the Chemung species remained. The reds, purples, and grays, and the white conglomerates, although some thousand feet in thickness, and carrying some fish bones and scales, and fragments of plants, show very little, if any, trace of marine life.

This series is terminated by the marshy land depositions of the Barclay coal mine.

I am under obligations to the Director of the United States Geological Survey for the insertion of this report in this place. The material was collected, and the work done on it privately in connection with my duties in Cornell University. The nature of the investigations having come to the notice of the Director, I was placed in position to continue them under the auspices of the Survey. This article is therefore included here as the first of a series of articles upon the comparative palæontology of the Devonian and Carboniferous faunas.

Although I am responsible for the opinions here advanced, I owe much to the suggestions and inspiration received from others. Especially valuable have been the numerous papers in which have been discussed the problems connected with the Devonian and Old Red Sandstone deposits of Great Britain and Europe. I may mention especially those of Messrs. Etheridge, Edward Hull, and T. M. Hall; also the papers of M. Jules Gosselet upon similar series in North France, and the interesting works of Joachim Barrande in other fields.

The writings of Professor Hall have been of great value, and the suggestions appearing all along in his works have often been in mind during these investigations.

ITHACA, N. Y., *December*, 1883.

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