THE AUSABLE CHASM. GRAND FLUME, LOOKING DOWNWARD FROM THE RAPIDS.
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University of the State of New York

NEW YORK STATE MUSEUM

Forty-seventh Annual Report

OF THE

REGENTS

For the Year 1893

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FORTY-SEVENTH ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

To the Legislature of the State of New York

I have the honor to submit herewith, pursuant to law, as the 47th annual report of the regents of the University on the New York State Museum the report of the director of the museum with appendices, of the botanist and the entomologist.

ANSON JUDD UPSON

Chancellor

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Regents standing committee on the State Museum

T. Guilford Smith, *Chairman*

Lieutenant-Governor, Superintendent of Public Instruction, Regents Bostwick, Beach, Cobb, C. E. Smith, Stimson

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State Museum Staff

Scientific Research

James Hall, M. A. (Rensselaer Polytechnic), LL. D. (Harvard) *State Geologist and Paleontologist*

Charles H. Peck, M. A. (Union) – – – *State Botanist*

J. A. Lintner, Ph. D. – – – – – *State Entomologist*

John M. Clarke, M. A. (Amherst) – *Assistant Paleontologist*

E. Emmons – – – – – – – – *Draftsman*

Philip Ast – – – – – – – *Lithographer*

Martin Sheehy – – – – – – – *Messenger*

Jacob Van Deloo – – – – – – – *Clerk*

Rose Davis – – – – – *Entomologist's Assistant*

Administration

Frederick J. H. Merrill, Ph. D. (Columbia) – *Assistant Director*

William B. Marshall, M. S. (Lafayette) – *Assistant Zoologist*

Edward L. Hanes – – – – – *Stenographer*

Joseph Morje – – – – – – – – *Page*

NEW YORK STATE MUSEUM.

Report of the Director, 1893.

REPORT OF THE DIRECTOR.

ALBANY, N. Y., *June* 24, 1893.

To the Honorable the Regents of the University of the State of New York:

GENTLEMEN.— Under date of May 10th, I received a communication from the Secretary of the Regents; a copy of which is herewith communicated.

REGENTS' OFFICE, ALBANY, N. Y., 10 *May*, '93.

To the members of the museum staff:

We all understand that the value of the scientific reports is greatly lessened by the delays in printing them. Careful investigation shows that we shall not escape the annual difficulty unless our reports can be brought in early in the summer, examined by the regents and actually printed in the fall. After considering the desirability of securing prompt printing and finding this to be the only way, the museum committee have passed the following:

"*Resolved*, That members of the museum staff be requested to present their annual reports of their scientific work to the regents in July of each year, in order that such reports may be submitted to the regents in print before the preparation of their annual report to the legislature."

As it is so late in the year I suggest that the report for this year be a short one, getting whatever you may be able to submit by August 1, or September at the latest. The state printer agrees to print in October and we can thus get started on the new system.

MELVIL DEWEY
Secretary

Owing to my plans for work upon the geologic map, I can only bring my report up to the first of July, since I have arranged to take the field, with an assistant, at that time.

It should be understood that a report made at this season of the year can cover only laboratory work, since field work is in such an unfinished condition that no results have been obtained which can be satisfactorily communicated in a report for publication.

The annual report upon the State Museum made in December, 1892, contains the communications of Mr. Merrill, Assistant Geologist, Mr. Marshall, Assistant Zoologist; a general inventory of the duplicate collections of fossils originally made for the Palæontology of New York; a statement of the additions to the Museum collections during 1892; the report of the Director upon the condition of the Palæontological department, and a list of the type specimens in the collections at the State Hall; together with a statement of the condition of the work upon the Palæontology of the State. This report was intended to bring up the record of work done to the end of the year 1892.

Since the date of that report the laboratory work has been continued as before. Mr. Martin Sheehy and Mr. E. Emmons have been at work upon the duplicate collections of fossils, assorting and selecting the better specimens to be preserved in the Museum collections; arranging a series of twenty school collections, and packing in boxes the superfluous material after making the selection of these twenty school sets. When completed these sets will each contain several hundred specimens. It is impossible just now to state how many specimens because the work is in progress. The duplicate material beyond the Museum collection and the school sets has been packed in boxes in systematic order; these boxes, numbering at the present time over one hundred, are piled in the rotunda of the State Hall, each one being marked with the name of the class of fossils which it contains.

Besides this work Mr. Sheehy, in charge of the machinery, has been cutting and shaping a great number of the larger rough specimens from the Livonia salt shaft, so as to preserve the fossils and to adapt them to convenient arrangement in the Museum collections. He has also, besides this work and the distribution of collections, made thirty-three sections of crystalline rocks for Mr. Merrill. In the distribution of specimens more than two hundred boxes have been opened and assorted, and the better specimens selected for the Museum and the school collections; the remainder having been repacked in boxes, as above stated. Of the duplicate material, of which a general inventory was presented in my last report, all the specimens from the geological formations below the Hamilton group have been examined and specimens selected as just mentioned. The work is now going on in the Hamilton group and will be carried through the Chemung collections, probably during the present year.

The work on the Palæontology has been progressing as rapidly as could be done, since the order for printing this volume was given only on the 23d of January, 1893. There are now 176 pages in type. The printing has been suspended since May fifteenth, in consequence of other engagements of Messrs. Van Benthuysen. The manuscript of the remainder of the work in hand, is so far advanced that the volume can be completed before the first of January, unless some unforeseen delay on the part of the printer shall intervene. The lithographic printing was ordered to proceed on the fourth day of March last, and since that time 3,000 copies of plates XXXVII and XXXVIII and 1,000 copies each of plates XL, XLI, XLII, XLIV, XLVIII, LI, LII, LIV, LV and LXIV have been printed. The total number of plates printed for the volume is twenty-eight; of this number twelve were printed more than ten years ago, and four were printed in 1890; the remaining twelve were printed during 1892 and 1893. There are ten plates in the printer's hands or in progress of printing, and twelve others drawn on stone ready for the printer

Geologic Map.

Since my last report the geographic base for the geologic map has been completed and delivered at the office of the Director of the United States Geological Survey. The color plates are in preparation, and we hope to have completed copies of the map before the end of 1893.

Field work on the geologic map for the present season has been commenced, and through the kindness of Major Powell, Director of the United States Geological Survey, an assistant, Mr. N. H. Darton, has been assigned to work under my direction in the State of New York, and he will take the field with me the first of July. Mr. Darton will retain his position as assistant on the United States Geological Survey, his salary being paid at Washington, while we incur only his traveling and field expenses.

Major Powell has likewise directed Prof. W. B. Dwight, of Vassar College, to turn over the results of his work, which have been made under the auspices of the United States Geological Survey for some years past, for use in our geologic map.

Prof. Kemp, of Columbia College, who had already been working in Essex county, has agreed to work up that portion of country and prepare it for the geologic map by being paid field expenses for himself and assistants.

Prof. C. H. Smyth, of Hamilton College, will also work out the Huronian and the hematite areas in St. Lawrence and Jefferson counties.

Dr. F. A. Randall is working in the southwestern counties in tracing the extension of the lower carboniferous rocks of Pennsylvania into the State of New York, and expects to complete his work before the end of the season.

No results of field work upon the geologic map, for 1893, can be communicated at this time, as every one engaged upon the work is in the field.

Prof. J. M. Clarke will spend his vacation in the field in central and western New York in tracing the continuation of the Catskill and Oneonta sandstones, and their mergence into the Portage and Chemung groups, with a view to determining the limits between these formations. This work can only be done by a man having acquaintance with fossils.

I expect to be in the field during the early part of July and most of the time after the month of August; joining Mr. Darton in the first place in work along the Mohawk Valley; thence northward through Saratoga and Washington counties. At a later date I shall join him in the work in Oneida, Lewis and Jefferson counties, and thence to Allegany, Cattaraugus and Chautauqua counties to verify the work of Dr. Randall. I expect also to join Prof. Dwight in Dutchess county, and we will extend our observations into Columbia county, of which we have comparatively little critical knowledge of the geologic structure.

Plates of Volume VIII, Part II.

The following schedule of the plates of volume VIII part ii, the numbers and subjects, with the progress made in each one on June 22nd, will give a pretty clear idea of the condition of the volume in this part of the work. The text already in type is 176 pages, which contains descriptions of all the genera of fossils illustrated on plates XXI to LV, inclusive.

XXI	Spirifer	Printed 1876
XXII	"	" 1878
XXIII	"	" 1878
XXIV	"	" 1878
XXV	"	" } 1890
XXVI	Cyrtia and Syringothyris	" } 1890
XXVII	Syringothyris	" } 1890
XXVIII	Cyrtia	" } 1890
XXIX	Spirifer	In process of printing
XXX	"	Printed } 1873–1880
XXXI	"	" } 1873–1880
XXXII	"	" } 1873–1880
XXXIII	"	" } 1873–1880
XXXIV	"	" } 1873–1880
XXXV	" and Spiriferina	" } 1873–1880
XXXVI	" " "	" } 1873–1880
XXXVII	" " Cyrtina	" 1893
XXXVIII	"	" 1893
XXXIX	" Cyrtia, Ambocœlia, &c.	Drawn; not proved
XL	Whitfieldella	Printed, 1000 copies, 1893
XLI	Meristina, Kayseria, Hindella,	" 1000 " 1893
XLII	Merista, Pentagonia, Dicamara	" 1000 " 1893
XLIII	Meristella	In process of printing
XLIV	"	Printed, 1000 copies, 1893
XLV	Athyris. (Numbered XL)	Printed 1892
XLVI	"	Proved and lettered
XLVII	"	" "
XLVIII	Nucleospira	Printed, 1000 copies, 1893
XLIX	Trematospira, Parazyga }	Stone broken } 1893
L	Retzia, Rhynchospira, Camarospira }	250 copies printed } 1893
LI	Eumetria, Hustedia	Printed, 1000 copies, 1893
LII	Uncites, Clintonella	" 1000 " 1893
LIII	Leptocœlia	In process of printing

LIV	Atrypa....................	Printed, 1000 copies, 1893
LV	Zygospira, Cyclospira.......	" 1000 " 1893
LVI	Rhynchonella, Protorhyncha. Orthorhynchula, Rynchotrema Rynchotreta, Stenoschisma ..	Drawn; not proved
LVII	Camarotœchia	In hand
LVIII	Plethorhynchus, Uncinulus ..	"
LIX	Liorhynchus	"
LX	Pugnax, Hypothyris	"
LXI	Cyclorhina, Eatonia	"
LXII	Camarella, Syntrophia....... Camarophoria, Lycophoria...	"
LXIII	Porambonites, Parastrophia.. Anastrophia	Not drawn
LXIV	Pentamerus	Printed, 1000 copies, 1893
LXV	"	In process of printing
LXVI	"	"
LXVII	"	Drawn
LXVIII	"	Not drawn
LXIX	"	" "
LXX	" Capellinia	" "
LXXI	Sieberella, Barrandella	" "
LXXII	Gypidula, Pentamerella	" "
LXXIII	Stricklandinia, Amphigenia ..	Drawn
LXXIV	Amphigenia	In process of printing
LXXV	Rensselaeria	Drawn
LXXVI	"	In process of printing
LXXVII	"	Drawn
LXXVIII	Newberria..................	In process of printing
LXXIX	Centronella	Not drawn
LXXX	Cryptonella................	" "
LXXXI	Dielasma	" "
LXXXII	Tropidoleptus	" "
LXXXIII	Eichwaldia, Aulacorhynchus .	" "
LXXXIV	Miscellaneous	" "
LXXXV	"	" "

Total plates printed to this date..................	28
in process of printing	10
drawn on stone ready for printing...........	12
not drawn..................................	15
	65

Albany, *June* 6, 1893.

James Hall, LL. D., *Director:*

Sir.— The last annual report on the condition of the Palæontological department was rendered on December 1, 1892. During the six months which have since intervened the time of the Assistant Palæontologist has been exclusively devoted to duties connected with the preparation and publication of the Palæontology of New York. The services of Mr. G. B. Simpson, draughtsman, and Mr. Philip Ast, lithographer, have also been given to this work. Mr. Ebenezer Emmons was engaged early in the year to undertake the sorting and distribution of the extensive collection of palæozoic fossils in the State hall. The drawer space in this building has always been insufficient to accommodate and render accessible this collection. The necessity for a careful selection of the material, the reservation of the better grades, and the incorporation of extensive suites of specimens lying in boxes finally became urgent. The work was begun with the Cambrian formation and at present is upon the fossils of the Middle Devonian. Thus far 816 drawers of specimens have been selected, classified and reserved for the permanent collection of the Museum, containing about 20,000 specimens; 102 boxes of inferior grades have been packed and stored, and at the same time twenty school collections are being made up, each of which now contains about 150 specimens, or all together about 3,000 specimens. The preparation of these twenty collections will save the usual labor and cost of time entailed whenever suites of specimens are required for educational institutions.

One large collection of fossils, consisting of 808 species fully identified and labeled, was sent in February to the State Normal School at Plattsburgh.

Martin Sheehy has been employed as general assistant, doing lapidary and mechanical work as required and aiding with the packing and arrangement of the collection.

Accompanying is a list of the additions to the palæontological collections during the winter months covered by this report.

I am, sir,

Very respectfully yours,

J. M. CLARKE,

Assistant Palæontologist.

List of Additions to the Palæontological Department, January-May, 1893.

By Donation.

Charles Schuchert, New Haven, Conn.:

Fossils from the primordial limestone, Troy, N. Y.	31
Fossils from the Calciferous limestone, one-half mile northwest Saratoga on Adirondack railroad	20
Fossils from the Trenton limestone, Sugar-loaf hill, near East Albany	70
Fossils from the Upper Trenton, dam at Sandy Hill, N. Y.	10
Fossils from the Utica slate, Baker's Falls, Sandy Hill, N. Y.	29

Prof. J. M. Safford, Nashville, Tenn.:

Hallina Saffordi, Trenton limestone	75

By Collection.

D. D. Luther:

Dictyophyton, Chemung group, Ingleside, Steuben county	21
Actinodictya, Chemung group, Avoca, Steuben county	2
Total	258

I communicate herewith the statement of Mr. Clarke on the general condition of the Palæontology with a list of accessions to the collections from January to May.

By the end of the present year I shall be able to give a more detailed account of the condition of the duplicate collections in the State Hall. The school collections which have been selected and the duplicate collection of which the better specimens will have been arranged in drawers, and those of inferior character will have been packed in boxes and remain at the disposal of the Regents. In regard to these collections it should be understood that the greater part of them, and indeed almost the entire collection, was made for the Palæontology of New York previous to 1880, and it is from these that we have the large amount of duplicate material which can be distributed for school collections.

The later collections have been made for special objects, and no large quantity of material has been obtained.

In this connection I ought to state that from certain of our geologic formations within the State of New York there are almost no duplicates, and if it be desirable to make the school collections complete representations of the geologic formations within the State of New York, it will be necessary to make collections in the field, especially from the Hudson river, the Niagara and Clinton groups.

Of the two last formations just named, we are obliged to give in these collections illustrative specimens from the collections of Ohio and of Waldron, Indiana. The specimens of fossils from these localities are even better than our own, but they will not give to the student the true idea of the physical characters of the formation and the condition of the fossils from the typical localities within the State of New York. Were these collections to be used for students making critical study of the fossils and the rock formations the deficiency would be a serious one, but where such studies are not to be made, and if not considered desirable to teach the physical characters of the formations, the collections which we have the means of making for this object will serve the purpose very well.

The absence of specimens of fossils from the formations mentioned is due to the fact that no appropriations of money for the collection of fossils was ever made till after the completion of volume II of the Palæontology which embraced the description of fossils from the Potsdam sandstone to the Niagara group inclusive. At a later date I began the collecting of fossils from the older rocks, in order to provide material for completing the school sets, and we have a fairly large amount of material from the Trenton and lower limestones. This work, however, was suspended owing to the nonallowance of means for carrying it forward.

I believe I have in a previous report given some explanation in regard to the absence of duplicate specimens from certain New York formations.

Very respectfully submitted.

JAMES HALL,

State Geologist.

REPORT

ON THE

WORK OF THE STATE MUSEUM

FOR THE

Fiscal Year Ending September 30, 1893,

By Frederick J. H. Merrill, Ph. D., Assistant Director.

Report of the Assistant Director.

To the Regents of the University of the State of New York:

Gentlemen.— I beg to submit herewith my report for the fiscal year just ended. The report for this year is essentially a report of the work done in preparation for the scientific exhibit of the State at the World's Columbian Exposition. While it may appear somewhat paradoxical at first sight, it is nevertheless true that the past year has been one of very great benefit to the Museum; the manufacturers of the State have been brought into intimate relations with the Museum, the collections have been enlarged, the economic resources of the State have been grouped and widely advertised, the Museum staff has been demonstrated to be an efficient working staff, and, most important of all, the results of the scientific investigations of the economic resources of the State have been embodied in the preparation of a greater number of bulletins than any previous year has compassed. The Salt and Gypsum Bulletin, by the Assistant Director, was published in April, 1893, and will be discussed hereafter. The Bulletin on the Clays, the brick and pottery industries of the State, by Mr. Heinrich Ries, is ready for publication. A preliminary report on the bluestone and flagstone industry of New York was prepared by W. E. Eberhardt. A report on the oil and gas industry of New York was begun by Mr. D. A. Van Ingen. In addition to these reports, a mass of accurate information on the minor industries of the State has been collected, and can be formulated ready for publication in a very short time. It is useless to insist to your honorable body upon the desirability of the publication of these reports. The Assistant Director knows only too well the lack of funds, and recognizes that this, and this alone, prevents the dissemination of the information already in hand, and which would be of so much practical value to the taxpayers of the State.

By a vote of the Board of Regents, September 29, 1892, the Scientific Exhibit of New York State at the World's Fair was placed in charge of the New York State Museum, and the task of preparing this exhibit was assigned to the Assistant Director. It was his plan, in preparing this exhibit, to attain three objects:

1. To make as exhaustive a display as possible of the natural resources of the State for economic purposes.

2. To show the collections derived by loan from the State Museum, and those secured directly by purchase for the World's Fair Exhibit, in the methods of grouping and arrangement used by the best equipped museums of this country or Europe, and in the most suitable exhibition cases.

3. To arrange the groups with reference to their logical sequence, preparing in this connection a report of educational and economic value. It is desired, in short, to show the public a museum modeled after the best in this country and Europe, in which, by the limitation of the case, the specimens were all derived from New York State — to show the economic resources of New York, and to instruct objectively all who visited the exhibition.

As the State Museum comprises six departments, Palæontology, Economic Geology and Mineralogy, Botany, Zoology and Entomology, the exhibit of the Museum would naturally have been made on these lines, and was so carried out wherever it was possible.

It is probable that in the minds of scientists in this country and in Europe the name of the State Museum of New York has for many years been closely associated with that of Dr. James Hall, the State Palæontologist. The volumes on Palæontology prepared under Dr. Hall's direction which were exhibited, are in themselves a library of the subject, and the great number of valuable plates therein form a comprehensive exhibit of the palæontological specimens in the State Museum.

In addition was exhibited the Cohoes Mastodon, a unique and almost perfect specimen.

At the time that the work was placed in charge of the Assistant Director of the Museum, the State Botanist had already begun his work. In the judgment of Prof. Peck, it was desirable to make a selection of some one group and an exhaustive presentation thereof. He selected the Fungi, upon which he had for a long time been working, and in relation to which he had made many interesting discoveries of economic value. His careful, accurate and artistic work needs no words of praise to those who were so fortunate as to examine the same. To the farmer and epicure, the physician and the student, it is alike interesting and valuable.

Could Dr. Lintner, the State Entomologist, have had the strength to undertake an exhibit in his department, it would have been at once a revelation and a liberal education to the other States. Our own knows well the man and the work which has been the protection of the farm and the garden, the library and the parlor. But the pressure of his regular work was so great that he was reluctant to undertake new duties, at the expense, perhaps, of those already entered upon, and therefore decided to make no entomological exhibit.

More than one foreign judge was so complimentary as to state that no other similar exhibit compared with that of New York in the careful arrangement of specimens, attention to detail, and neat methods of display. In no one group is this careful, neat and even artistic arrangement more evident than in the land and fresh water shells, prepared by the Assistant State Zoologist, Mr. William B. Marshall. The specimens were almost all owned by the State Museum, but a few necessary additions were bought by the State Board of Managers. A series of the mammals of New York State were also exhibited.

The mineral exhibit was the most extensive of the exhibits made by the New York State Museum, and consisted of two collections; the scientific collection of minerals in the west gallery, and the collection of economic minerals in the Mining Exhibit on the main floor. The former has accumulated through many years and is of great educational value. It contains, moreover, many large and particularly fine specimens which can not be duplicated. Mr. Lea M. Luquer, the Assistant in Mineralogy at Columbia College, was placed in charge of the selection, examination, cataloguing and arrangement of the minerals of the Museum which formed this very beautiful exhibit.

The mining exhibit was almost entirely collected for the World's Columbian Exposition, and represents, as fully as possible, the mining resources of New York State. Although New

York does not rank as a mining State, its mining products are of great value, the brick industry alone amounting to $8,500,000 a year. The product of its quarries of building stone is enormous, although an accurate statement of its annual value can not yet be made. The salt industry amounts to over $1,500,000 a year. A large amount of capital is invested in the iron industry of New York, although the present state of the iron market has closed many of the mines. The clay industries of the State, the brick and pottery works, have now become an important source of income to many residents of New York, and are the fountain-head of much interstate commerce. Early in his official life in Albany, the Assistant Director recognized the propriety of a bulletin of reliable information on the subject of the clay industry, and secured the services of Mr. Heinrich Ries, Ph.B., who has visited all the works of the State manufacturing articles from this material, and has prepared, under Dr. Merrill's direction, a full and very valuable bulletin upon the clays of New York. It is a matter of great regret that the necessary funds have not been in hand to publish this bulletin of so much use to the taxpayers. The clay collections for the exhibit at the World's Fair were made by Mr. Ries, who was also the Assistant in charge of the installation of the mining exhibits, and discharged his duties in a manner alike creditable to himself and the State.

The iron ores exhibited by the State were obtained by correspondence and supplemented by specimens from the Museum.

The mineral waters of New York State are so well known as to require no comment, but an entire case was devoted to samples from the various springs and wells, representing an industry of considerable financial value.

"The Salt and Gypsum Industries of New York" form Bulletin No. 11, Vol. 3, of the publications of the New York State Museum, by Frederick J. H. Merrill. This Bulletin is in itself explanatory of the State salt exhibit at the World's Fair. It consists of 89 pages, and contains a map showing the geographical distribution of the Salina Group of rocks in New York, and the locations of salt wells and of quarries of gypsum; and a map of the salt district of Genesee, Wyoming and Livingston counties, showing the locations of productive and unproductive salt wells and mines, and the underground contours of the salt beds.

The Bulletin contains also 11 tables, showing in detail various features of the salt and gypsum industries. It is illustrated by 12 plates. The Assistant Director experienced great difficulty in securing satisfactory specimens of salt for display. Mr. R. D. White, C. E., was first sent out to visit the manufacturers of salt in the State, and to select and arrange for the shipment of the different kinds of salt. The companies did not feel that the exhibits would be of financial value to them, and were reluctant to involve themselves in any expenditure of time or labor. It became necessary to send Mr. William C. Clarke, E. M., on an additional trip before satisfactory arrangements could be made to present a proper exhibit.

The study of the gypsum industry had already been placed in the hands of Mr. Clarke, who ably conducted the examination. The value of this industry is considered in the same report.

The building stones of the State were prepared for exhibition in ten-inch cubes, one face receiving as high a polish as the stone was susceptible of, and the other faces being prepared so as to bring out the individual peculiarities of the stone. The work of cutting and polishing these stones was done by the firm of Schilling & Co., of Albany, who also prepared the stones for the geological obelisk.

A prominent feature of the mining exhibit was an obelisk of stone from the various geological formations of New York, arranged in layers of proportionate thickness, on a scale of fifty feet to the inch, and of which the proportions are those of Cleopatra's needle, in Central Park. The idea of a geological column was first suggested by Prof. Hall, who exhibited a pyramid at the New Orleans exposition in 1885–6, but it was found advisable by the Assistant Director to adopt a form and plan different from that of Dr. Hall, and the proportions of the Egyptian obelisk were chosen, as exhibiting greater elegance of form, and being more economical of ground space. The geological obelisk was composed of all the solid rock formations occurring in New York, in their regular succession, from the Archæan to the summit of the Trias. The four sides of the obelisk show the occurrence of the formations in the respective quarters of the State, each formation being represented by one or more courses, proportionate to its relative thickness in New York. The courses are lettered as follows:

		No. of courses.
	Cap and Top Course, Trap and Triassic Sandstone.	
V.	Olean Conglomerate (Carboniferous)	1
	Catskill	2
	Portage	5
U.	Chemung	5
	Genesee	1
	Tully	1
T.	Hamilton	4
S.	Marcellus	1
R.	Upper Helderberg, or Corniferous	2
P.	Schoharie	1
O.	Caudagalli	1
N.	Oriskany	1
M.	Lower Helderberg	2
L.	Salina	4
K.	Niagara	2
J.	Clinton	1
I.	Medina	4
H.	Oneida	1
G.	Hudson River	5
F.	Trenton	1
E.	Chazy	1
D.	Calciferous	1
C.	Potsdam	1
B.	Acadian	2
A.	Georgia	6
	Base, Archæan Granites and Gneisses.	

Thanks are due to Prof. William B. Dwight, of Vassar College, for his laborious efforts to secure, at a time when the winter weather made it a matter of great difficulty, stones from the Cambrian formation of Washington county.

Several propositions were made to secure the obelisk for educational institutions, but the board of managers reserve it for he State.

Through the liberality of the board of general managers of the State of New York, it was possible to install and arrange this exhibit in such a manner that it received high praise from all the judges detailed to examine it.

Mr. Isaac G. Perry, State Commissioner of the New Capitol, deserves public recognition for the interest and ability shown in his design for the New York State Mining Pavilion.

The Assistant Director's efforts have been seconded with uniform cordiality and willingness by all his assistants, and he desires here to express to them his thanks.

Notwithstanding the difficulties, the work has been from the beginning to the end of great interest and pleasure to the Assistant Director of the State Museum.

In January, a self-registering turnstile was placed at the entrance door of Geological Hall for the purpose of obtaining a record of the number of visitors. According to the record furnished by this turnstile, between February 1 and October 1, 1893, 54,660 persons entered the building. This would be an average of 6,832 per month for eight months, and an average of 264 per day for the 207 days. The daily attendance varied from 56, the lowest, on April first, to 855, the highest, on May thirtieth. The average daily attendance in the month of July, August and September was 343, 344 and 356 per day respectively, greatly exceeding the average daily attendance in other months. This is probably due to the fact that these three months cover the period in which there is an unusual number of people passing through Albany on their way to or from the various summer resorts. These months cover also the season in which many day excursions visit Albany.

Since the date of the last report, collections (of minerals) have been deposited with the following schools in this State: East Bloomfield Union School, Lockport Union School, Forestville Free Academy, Sherman Union School.

Formerly, collections sent to the various schools ceased to be the property of the Museum. Under present regulations, these collections are now simply deposited with the schools to which they are sent. Each school receiving a collection agrees "that such collection shall have provision for suitable care and convenient use," and "accepts the deposit of such collection with the distinct understanding that it remains the property of the New York State Museum, and is subject to recall by the Regents."

The report of the Assistant Zoologist is appended.

In conclusion, the Assistant Director desires to express his thanks to the Regents for the leave of absence granted by them; to the secretary of the board for his efforts to promote the work of the Museum during the Assistant Director's enforced absence; to the Assistant Zoologist for his attention to the Museum correspondence and other details of the routine work of the Museum, for statistics in regard to the turnstile and the school collections, and for his uniform willingness and cordial co-operation. The wisdom of the Regents in placing in charge of the State Museum the work of preparing the scientific exhibit at the World's Columbian Exposition has secured for the Museum interest, advertisement, specimens and much valuable information without incurring any expense whatever.

The Assistant Director looks forward with pleasure to the work of the ensuing year, which he hopes to begin in April. It is a year of promise, and he trusts that he may do his part in promoting a full fruition.

Respectfully submitted.

F. J. H. MERRILL,
Assistant Director.

ALBANY, *December* 7, 1893.

Dr. F. J. H. MERRILL, *Assistant Director of the N. Y. State Museum:*

DEAR SIR.— I submit herewith the following brief summary of the work of the Assistant Zoologist for the period beginning December 1, 1892, and ending September 30, 1893. During this period a large part of my time has been devoted to the preparation of exhibits for the World's Columbian Exposition.

In the department of Anthropology and Ethnology the exhibit consisted of a collection of stuffed animals illustrating the present and historic mammalian fauna of this State; a collection of the land and fresh-water shells of New York; and the mastodon found at Cohoes in 1866. The greater part of my time from the 1st of January to the 1st of June was spent in preparing the two zoological exhibits. In May I spent twelve days in Chicago attending to their installation.

Copies of my reports on the two zoological exhibits are appended to this report.

Most of the specimens shown in the exhibit of land and fresh-water shells were taken from the Museum collections. Valuable contributions of specimens of species altogether lacking in our own collection or represented only by inferior specimens were received from several gentlemen interested in this subject. In some cases all the specimens contributed were not made part of the collection to be exhibited. The list of additions to the Zoological Department will show the number of species and specimens contributed, and the catalogue of the species exhibited at the World's Fair will show to what extent the donations were drawn upon in making up the exhibit.

All the specimens shown in the exhibit of mammals were taken from the Museum collections. The Assistant Zoologist indicated what animals should be shown in the exhibit and Ward's establishment at Rochester was engaged to send experienced men to Albany to pack the specimens and ship them to Chicago. The same men attended also to shipping the mastodon and mounting it in Chicago. The specimens will receive the same careful attention when being returned to Albany.

During the year I have reidentified the shells belonging to the following families, using Tryon's Manual of Conchology as my guide:

Terebridæ, Cancellariidæ, Strombidæ, Cypræidæ, Ovulidæ, Cassididæ, Doliidæ, Naticidæ, Calyptræidæ, Turritellidæ, Pyramidellidæ, Solariidæ, Ianthinidæ, Trichotropidæ, Scalariidæ, Cerithiidæ, Littorinidæ.

The rearrangement of the conchological collection has progressed satisfactorily. At present the arrangement is completed through the family Conidæ according to the system of Tryon. The general plan followed in arranging this collection has been described in the reports for 1891 and 1892, so that it is not necessary to give details here. The catalogue of shells, which was begun in the Report for 1891 is continued in this report. An appendix hereto contains a catalogue of eleven families.

At the risk of making the subject tiresome I venture to call attention once more to the fact that the Museum is in need of more space in which to exhibit specimens and for working rooms. For several years past our annual reports have discussed this subject more or less fully, so that it is unnecessary to enter into details at this time. It may be well, however, to quote the following from the Report of the Director for 1890: "I would most earnestly recommend the concentration of the Museum and its offices in a well-lighted, fire-proof building, where we may have at least *thirty-two thousand square feet available for exhibition purposes alone*, with the possibility of additional space to accommodate the growth and increase in each one of the departments. In addition to this, there should be ample space for offices and laboratories with the convenience of a working library in each one.

In the matter of being provided with facilities commensurate with increasing needs the State Museum has not received the consideration which it merits, and which has been bestowed upon other institutions in Albany and elsewhere. In the city of Albany the State Normal College, the Dudley Observatory and the State Armory may be cited as institutions which have been appreciated at their full value and which have recently been provided with buildings and other equipments suitable to their purposes.

The American Museum of Natural History in New York city has received the most generous private and municipal support, and has just completed a large addition to its magnificent building.

Within the last two or three years the Academy of Natural Sciences in Philadelphia has built an addition several times larger than its original building. The necessary means were provided by the State, the city, and private individuals.

Attention is invited also to the small sum allowed for the support of the departments of the Museum located in Geological Hall. At present only $5,000 dollars per annum are available for salaries, purchase and collection of specimens, printing and all other expenses. This amount would be hardly more than sufficient properly to provide for the needs of the zoological department alone, which in addition to the services of a zoologist should have also the services of a taxidermist, and funds to provide for a continual increase and proper display of the collections.

Respectfully submitted.

WILLIAM B. MARSHALL,
Assistant Zoologist.

Necturus maculatus in the Hudson River.*

In Prof. Cope's Monograph of North American Batrachia (United States National Museum Bulletin No. 34), an interesting feature of the geographical distribution of the Mud Puppy, Necturus maculatus, Raf.— has been overlooked, viz.: the fact that through the agency of canals the species has been introduced into the Hudson River, and has become abundant both in the river and its various tributaries.

Prof. Cope gives the habitat of the species as follows: "Ranges throughout the tributaries of the great lakes and the Mississippi, as well as the rivers that flow into the Gulf of Mexico and the Atlantic Ocean as far north as the Tar River, North Carolina."

Only one New York locality is cited, Grass River, St. Lawrence county. This is a tributary of the St. Lawrence River, and its source is not very far distant from the source of the Hudson. The only other locality cited which is at all near the Hudson is Burlington, Vermont.

This locality also is in the drainage area of the St. Lawrence. Both the localities cited are covered by the statement "ranges throughout the tributaries of the Great Lakes," but there is nothing to indicate that the species inhabits the Hudson and tributaries.

DeKay, in 1842 (Natural history of the State of New York), predicted that the species would some day be found inhabiting the Hudson. DeKay's exact words on the distribution of the Mud-Puppy in the State of New York were as follows: "This curious and interesting aquatic animal is common in the northern and western parts of the State. It is found in Lake Champlain, and is particularly abundant at the Falls of the Onion River and at the outlet of Lake George. It inhabits Lakes Erie, Seneca, and the other lakes in the western districts of New York. It has been found in the Erie canal, and will doubtless, ere long, be found to have reached the Hudson River." De Kay's prediction has come to be a fact. Whether the species came from the west through the Erie canal, or from Lake Champlain through the Champlain canal, it is now so abundant in the neighborhood of Albany as to be somewhat of a nuisance. The city

* Reprinted from the *American Naturalist.*

reservoirs are plentifully stocked with the species. A short time ago an individual was washed out of one of the fire-plugs in the heart of the city, and report says that another became wedged in the water-pipes of one of our school-houses and had to be cut out in order to allow the water to flow.

As the Hudson and Delaware Rivers are connected by a canal which runs from Kingston on the Hudson to Port Jervis on the Delaware it is not improbable that the Mud-Puppy will at some future time be found in the Delaware.

At present no record of its occurrence in the Delaware is known to me, and probably it has never yet been found in that river. At least no mention of the species is made in Dr. C. C. Abbot's Catalogue of the Vertebrates of New Jersey, published in 1868, nor in Julius Nelson's revision of the same catalogue, published in 1890.

The presence of the species in the Hudson and its tributaries is worthy of note, as it is one of the very few instances in which we have apparently good evidence that the habitat of an aquatic animal has been unintentionally enlarged through human agency.

WM. B. MARSHALL,
Albany, N. Y.

Additions to the Collections.

Zoology.

From Rev. W. M. Beauchamp, Baldwinsville, N. Y., shells from Onondaga county, N. Y., as follows:

Unio alatus, Say, Cross Lake, one specimen.
Unio alatus, Say, Seneca River, one specimen.
Unio gracilis, Barnes, Cross Lake, one specimen.
Unio rubiginosus, Lea, Erie Canal, three specimens.
Unio ventricosus, Barnes, Seneca River, five specimens.
Unio occidens, Lea, Seneca River, five specimens.
Unio cariosus, Say, Cross Lake, one specimen.
Unio cariosus, Say, Seneca River, two specimens.
Unio luteolus, Lam., Cross Lake, ten specimens.
Unio luteolus, Lam., Erie Canal, three specimens.
Unio radiatus, Lam., Erie Canal, one specimen.
Unio parvus, Barnes, Erie Canal, seven specimens.
Unio complanatus, Sol., Erie Canal, three specimens.
Unio rectus, Lam., Seneca River, five specimens.
Unio Novi-Eboraci, Lea, Erie Canal, sixteen specimens.
Unio Novi-Eboraci, Lea, Seneca River, six specimens.
Unio Tappanianus, Lea, Erie Canal, six specimens.
Margaritana rugosa, Barnes, Erie canal, one specimen.
Margaritana rugosa, Barnes, Onondaga Lake, one specimen.
Margaritana rugosa, Barnes, Cross Lake, three specimens.
Margaritana rugosa, Barnes, Seneca River, two specimens.
Anodonta fragilis, Lam., Beaver Lake, six specimens.
Anodonta fragilis, Seneca River, two specimens.
Anodonta Benedictii, Lea? Onondaga Lake, one specimen.
Anodonta edentula, Say, Erie Canal, six specimens.
Anodonta fluviatilis, Dillw., Skaneateles Lake, seven specimens.
Anodonta fluviatilis, Dillw., Erie Canal, eighteen specimens.
Anodonta fluviatilis, Dillw., Seneca River, seven specimens.
Pleurocera subulare, Lea, Erie Canal, twenty-one specimens.
Goniobasis livescens, Menke, Seneca River, seventeen specimens.

Goniobasis depygis, Say, Baldwinsville, twenty-one specimens.
"Valvata arenifera," Lea=Larva cases of insect Phrygania, Oneida River, eleven specimens.
Bithynella obtusa, Lea, Onondaga county, twenty-one specimens.
Limnæa pallida? Adams, Cross Lake, fifty specimens.
Limnæa catascopuim, Skaneateles Lake, seventeen specimens.
Limnæa caperata, Say, Oneida River, two specimens.
Limnæa gyrina, Say, Baldswinsville, thirty-four specimens.
Physa heterostropha, Say, fifty specimens.
Bulinus hypnorum, Linn., Baldwinsville, fifty-five specimens.
Succinea avara, Say, Baldwinsville, twenty-two specimens.
Also Limnæa emarginata, Say, Oswego, N. Y., nine specimens.
Pupa muscorum, Linn., Rochester, N. Y., twenty specimens.

From Shelley G. Crump, land and fresh-water shells from Pittsford, N. Y., as follows:

Unio alatus, Say, one specimen.
Unio gracilis, Barnes, two specimens.
Unio pressus, Lea, two specimens.
Unio undulatus, Barnes, eight specimens.
Unio rubiginosus, Lea, five specimens.
Unio occidens, Lea, two specimens.
Unio luteolus, Lam., four specimens.
Unio complanatus, Sol., four specimens.
Unio rectus, Lam., two specimens.
Unio nasutus, Say, four specimens.
Unio novi Eboraci, Lea, four specimens.
Unio gibbosus, Barnes, five specimens.
Margaritana rugosa, Barnes, two specimens.
Anodonta fragilis, Lam, four specimens.
Anodonta edentula, Say, five specimens.
Anodonta undulata, Say, two specimens.
Anodonta Lewisii, Lea, two specimens.
Anodonta Ferussaciana, Lea, six specimens.
Anodonta subcylindracea, Lea=A. Ferussaciana, Lea, three specimens.
Sphærium sp?
Goniobasis Virginica, Gmel., six specimens.
Goniobasis Virginica, Gmel., } five specimens.
Goniobasis, var. multilineata, Say, }
Goniobasis depygis, Say, ten specimens.
Pleurocera subulare, Lea, five specimens.
Bythinia tentaculata, Linn., fourteen specimens.

Gillia altilis, Lea, thirty-five specimens.
Valvata, tricarinata, Say, twenty-one specimens.
Melantho decisa, Say, seventy-five specimens.
Limnæa stagnalis, Linn., five specimens.
Limnæa reflexa, Say, six specimens.
Limnæa elodes, Say, five specimens.
Limnæa desidiosa, Say, eleven specimens.
Limnæa catascopium, Say, five specimens.
Limnæa pallida, Adams, four specimens.
Physa ancillaria, Say, seven specimens.
Physa heterostropha, Say, eleven specimens.
Bulinus hypnorum, Linn., five specimens.
Planorbis campanulatus, Say, ten specimens.
Planorbis trivolvis, Say, thirteen specimens.
Planorbis bicarinatus, Say, eight specimens.
Planorbis parvus, Say, sixteen specimens.
Segmentina armigera, Say, sixteen specimens.
Macrocyclis concava, Say, seven specimens.
Zonites fuliginosus, Griff., eight specimens.
Zonites inornatus, Say, seven specimens.
Zonites intertextus, Binn., six specimens.
Zonites arboreus, Say, nineteen specimens.
Zonites indentatus, Say, three specimens.
Zonites multidentatus, Binn., two specimens.
Patula alternata, Say, nine specimens.
Patula perspectiva, Say, thirteen specimens.
Patula striatella, Anthony, thirty-one specimens.
Helicodiscus lineatus, Say, two specimens.
Stenotrema hirsutum, Say, four specimens.
Stenotrema monodon, Rack., seven specimens.
Vallonia pulche la, Müll., seven specimens.
Triodopsis palliata, Say, five specimens.
Triodopsis tridentata, Say, eleven specimens.
Triodopsis fallax, Say, four specimens.
Mesodon albolabris, Say, six specimens.
Mesodon thyroides, Say, seven specimens.
Mesodon Sayii, Binney, three specimens.
Pupa muscorum, Linn., forty-five specimens.
Ferussacia subcylindrica, Linn., thirteen specimens.
Succinea ovalis, Gould, five specimens.
Succinea obliqua, Say, four specimens.

From James Delaney, Rochester, N. Y., shells as follows:

Unio gracilis, Barnes, Erie Canal, Rochester, N. Y., one specimen.

Unio nasutus, Say, Erie Canal, Rochester, N. Y., one specimen.

Margaritana deltoidea, Lea, Mud Creek, N. Y., one specimen.

Anodonta edentula, Say, Honeoye Creek, Monroe county, N. Y., one specimen.

Anodonta Ferussaciana, Lea, Honeoye Creek, Monroe county, N. Y., one specimen.

Anodonta Ferussaciana, Lea, Erie Canal, Syracuse, N. Y., one specimen.

Zonites fuliginosus, Griff., Rochester, N. Y.

Pupa muscorum, Linn., Rochester, N. Y.

From Albert Bailey, Chepatchet, Herkimer county, N. Y., land and fresh-water shells from Herkimer county, N. Y., as follows:

Valvata sincera, Say, Winfield, ten specimens.

Limnæa humilis, Say, Winfield, eight specimens.

Bulinus hypnorum, Linn., Winfield, ten specimens.

Planorbis trivolvis, Say, Winfield, five specimens.

Macrocyclis concava, Say, Winfield, ten specimens.

Vitrina limpida, Gould, Winfield, ten specimens.

Zonites fuliginosus, Griff., Winfield, five specimens.

Patula perspectiva, Say, Winfield, eight specimens.

Patula striatella, Anth., Winfield, ten specimens.

Triodopsis palliata, Say, Winfield, five specimens.

Mesodon albolabris, Say (dentate variety), Winfield, two specimens.

Mesodon Mitchellianus, Lea, Litchfield, five specimens.

Mesodon elevatus, Say, Litchfield, three specimens.

Mesodon exoletus, Binn., Litchfield, three specimens.

Mesodon dentifera, Binn., Litchfield, two specimens.

Mesodon Sayii, Binn., Winfield, three specimens.

Succinea obliqua, Say, Winfield, five specimens.

From W. S. Teator, Upper Red Hook, N. Y., shells as follows:

Helix palliata, Say, Annandale, Dutchess county, N. Y., December, 1892, eight specimens.

Helix albolabris, Say, Annandale, Dutchess county, N. Y., December, 1891, seven specimens.

Helix thyroides, Say, Annandale, Dutchess county, N. Y., December, 1892, seven specimens.

Helix thyroides, Say, Elizaville, Columbia county, N. Y., December, 1891, six specimens.

Succinea obliqua, Say, Upper Red Hook, Dutchess county, N. Y., December, 1892, eighteen specimens.

Succinea obliqua, Say, Annandale, Dutchess county, N. Y., August, 1890, twelve specimens.

Succinea avara, Say, Fort Washington, New York city, June, 1890, seventeen specimens.

Anodonta fluviatilis, Dillw., Dover Plains, Dutchess county, N. Y., 1890, three specimens.

From Prof. Geo. H. Hudson, Plattsburgh, N. Y.:

Anodonta Benedictii, Lea, Lake Champlain (Typical locality), one specimen.

From T. M. Fry, Syracuse, N. Y.:

Unio pressus, Lea, Mannsville, Jefferson county, N. Y., two specimens.
Unio radiatus, Lam., Seneca River, N. Y., two specimens.
Limnæa reflexa, Say, Antrim county, Michigan, two specimens.
Pupa pentodon, Say, Jefferson county, N. Y., seven specimens.
Pupa armifera, Say, Yates county, N. Y., sixteen specimens.

From Dr. S. Hart Wright, Penn Yan, Yates county, N. Y.:

Unio ventricosus, Barnes, Tonawanda Creek, Niagara county, N. Y.
Unio occidens, Lea, Tonawanda Creek, Niagara county, N. Y.
Unio parvus, Barnes, Genesee Canal, Monroe county, N. Y.
Anodonta Ferussaciana, Lea, Keuka Lake, Yates county, N. Y.

Rev. John Walton, Rochester, N. Y., shells from the vicinity of Rochester, N. Y., as follows:

Unio rectus, Lam., three specimens.
Unio Novi-Eboraci, Lea., four specimens.
Unio pressus, Lea, three specimens.
Unio luteolus, Lam., three specimens.
Unio luteolus, Lam., var. rasacens, De Kay, three specimens.
Unio alatus, Say, one specimen.
Unio rubiginosus, Lea, four specimens.
Unio nasutus, Say, three specimens.
Unio occidens, Lea, one specimen.
Unio radiatus, Lam., one specimen.
Unio undulatus, Barnes, four specimens.
Unio complanatus, Sol., two specimens.
Unio gibbosus, Barnes, three specimens.
Unio gracilis, Barnes, three specimens.
Margaritana deltoidea, Lea, one specimen.
Anodonta Benedictii, Lea, one specimen.
Anodonta subcylindracea, Lea, four specimens.
Anodonta ferruginea, Lea (=edentula, Say), three specimens.
Gillia attilis, Lea, lot.

Bythinia tentaculata, Linn., lot.
Limnæa catascopium, Say, lot.
Limnæa elodes, Say, lot.
Physa heterostropha, Say, lot.
Physa ancillaria, Say, lot.
Physa gyrina, Say, lot.
Planorbis trivolvis, Say, lot.
Planorbis bicarinatus, Say, lot.
Planorbis parvus, Say, lot.
Planorbis hirsutus, Gould, lot.
Planorbis deflectus, Say, lot.

MAMMALS OF NEW YORK

EXHIBITED AT THE

WORLD'S COLUMBIAN EXPOSITION,

CHICAGO, ILLINOIS.

1893.

Exhibit of New York Mammals.

Frederick J. H. Merrill, Ph. D., *Director of the Scientific Exhibit of the State of New York at the World's Columbian Exposition:*

Dear Sir.— I send you herewith a list of mammals exhibited by the State of New York at the World's Columbian Exposition.

Most of the specimens are from New York localities; but a few, especially of those animals that are now extinct in New York, are from localities outside of our State.

All of the specimens exhibited were loaned under proper authority by the New York State Museum.

Very truly yours.

WILLIAM B. MARSHALL,
Assistant Zoologist New York State Museum.

Albany, *November* 27, 1893.

Latin name.	Common name.	Specimen and sex.	Remarks.
Didelphys virginiana, Shaw	Opossum	Male and female	
Lepus sylvaticus, Bach	Wood hare	Three specimens	
Lepus americanus, Erx	Northern hare	Male and female	
Lepus americanus, Erx	Northern hare	One specimen	
Erethizon dorsatus, Linn	Canada porcupine	Male and albino	
Zapus hudsonius, Coues	Jerboa	One specimen	
Fiber zibethicus, Linn	Muskrat	Male and female	
Fiber zibethicus, Linn	Muskrat	One specimen	
Arvicola pinetorum, LeC	Pine mouse	One specimen	
Arvicola riparius, Ord	Meadow mouse	Male, male-albino and female	
Evotomys rutilus gapperi, Coues	Red-backed mouse	One specimen	
Hesperomys leucopus, Raf	White-footed mouse	One specimen	
Mus musculus, Linn	Common mouse	Male and female	Introduced from Europe.
Mus decumanus, Pallas	Brown rat	Male, male-albino, female, female-pied	Introduced from Europe.
Neutoma floridana, Ord	Wood rat	One specimen	
Castor fiber, Linn	Beaver	Group of two males, one female, two young	Extinct in New York. (See Note I.)
Arctomys monax, Linn	Woodchuck	One specimen	
Tamias striatus, Linn	Chipmunk	Three specimens	
Sciurus hudsonius, Erx	Red squirrel	Male, female and albino	
Sciurus carolinensis, Gmel	Grey squirrel	Five specimens	
Sciurus niger, Linn	Fox squirrel	Five specimens	

Sciuropterus volucella, Gmel	Flying squirrel	Male and female	
Sorex platyrhinus, De Kay	Broad-nosed shrew	One specimen	
Scalops aquaticus, Linn	Shrew-mole	Two specimens	
Scapanus americanus, Sartram	Hairy-tailed mole	Three specimens	
Sorex carolinensis, Bacham	Carolina shrew	Male	
Condylura cristata, Illiger	Starnose mole	Three specimens	
Vespertilio subulatus, Say	Little brown bat	Male and female	
Vesperugo noctivagans, LeC	Silver-haired bat	Male and female	
Atalapha noveboracensis, Erx	New York bat	Male and female	
Atalapha cinerea, Bean	Hoary bat	Male	
Cariacus virginianus, Bodd	Virginia deer	Male	
Cervus canadensis, Erx	Wapiti or elk	Male and female	Extinct in New York. (See Note II.)
Alce Alces, Linn. var. americanus, Jardins	Moose	Male and female	Extinct in New York. (See Note III.)
Bison americanus, Gmel	American bison or buffalo	Male and female	Formerly abundant in most parts of the United States; now extinct, except a few herds in the Yellowstone region.
Phoca vitulina, Linn	Harbor seal or common seal	Male	Formerly abundant in the Hudson river and Long Island sound, but rarely seen at present. (See Note IV.)
Crystophora cristata, Gmel	Hooded seal	Male and female	An accidental visitor to Long Island sound. (See Note V.)
Procyon lotor, Linn	Raccoon	Male and female	
Ursus americanus, Pallas	Black bear	Male	
Lutra canadensis, Turton	American otter	Female	

Latin name.	Common name.	Specimen and sex.	Remarks.
Mephitis mephitica, Shaw	Skunk	Male and female	
Gulo luscus, Brisson	Wolverine or glutton	Male	Extinct in New York. (See Note VI.)
Mustela americana, Turton	Sable or pine martin	Male	
Mustela pennant, Erx	Fisher or black cat	Male and female	
Putorius vision, Schreber	Mink	Three specimens	
Putorius erminea, Linn	Ermine weasel or stoat	Five specimens	
Putorius nivalis, Linn	Least weasel	One specimen	
Vulpes fulvus, Des	Red fox	Male and female	
Urocyon cinereo argentatus, Schreber	Grey fox	Male	
Canis lupus, Linn	Wolf	Two males	Nearly extinct in New York. (See Note VII.)
Lynx canadensis, Des	Canada lynx	Male	
Lynx rufus, Guld	Wild cat or bay lynx	Male and female	
Felis concolor, Linn	Panther cougar or puma	Male, female and kittens	Nearly extinct in New York. (See Note VIII.)

Note I.—The Beaver.

"According to a letter from the Dutch West India Company, preserved in the Albany Records, we learn that, in 1624, 400 beavers and 700 otter skins were exported; the number increased in 1635 to 14,891 beaver and 1,413 otter skins; and the whole number in the ten years was 80,183 beavers and 7,347 otters, amounting in value to 725,117 guilders."—De Kay, Zoology of New York, 1842.

The beaver, once abundant and of great commercial importance, is still perhaps entitled to be considered an inhabitant of New York. "At present there is a small colony of beavers on a stream that empties into the west branch of the St. Regis river. It is probably the colony referred to by De Kay, in 1842, as 'yet existing in the southern part of Franklin county.' It is to be earnestly hoped that the hunters who frequent that part of the wilderness will spare no pains to protect these animals from molestation."—Merriam, Mammals of the Adirondacks, 1884.

Note II.—The Wapiti, or American Elk.

"The stag is still found in the State of New York, but very sparingly, and will doubtless be extirpated before many years. Mr. Beach, an intelligent hunter on the Racquet, assured me that, in 1836, he shot at a stag (or, as he called it, an elk) on the north branch of the Saranac. He had seen many of the horns and described this one as much larger than the biggest buck (C. virginianus), with immense long and rounded horns with many short antlers. His account was confirmed by another hunter, Vaughan, who killed a stag at nearly the same place. They are found in the northwestern counties of Pennsylvania and the adjoining counties of New York. In 1834, I am informed by Mr. Philip Church, a stag was killed at Bolivar, Allegany county. My informant saw the animal, and his description corresponds exactly with this species."—De Kay, Zoology of New York, 1842.

"That the American elk, or wapiti (Cervus canadensis), was at one time common in the Adirondacks, there is no question. * * * When the species was exterminated here is not known. * * * I do not regard the above account of Messrs. Beach and Vaughan as trustworthy, for the reason that I have never been able to find a hunter in this wilderness, however aged, who had ever heard of a living elk in the Adirondacks."—Merriam, Mammals of the Adirondacks, 1884.

Note III.—The Moose.

The bull moose exhibited was killed in the town of Ohio, Herkimer county, New York, in January, 1851. Ten years later the moose was exterminated in New York.

Note IV.—The Harbor Seal—Common Seal.

Harbor seals "are now comparatively rare in our waters, but were formerly very abundant. A certain reef of rocks in the harbor of New York is called *Robin's Reef*, from the numerous seals which were accustomed to resort there; *robin* or *robyn* being the name in Dutch for seal. At some seasons, even at the present day, they are very numerous, particularly about the Execution Rocks in the Sound; but their visits appear to be very capricious. * * * In the Kingston (N. C.) Chronicle of February, 1823 or '24, there is a notice of a seal having been taken on the ice on Lake Ontario, near Cape Vincent (Jefferson county), this State. The paper gives no description, but asserts, on the authority of Indian traders, that seals have heretofore been seen on the borders of the lake, though the circumstance is one of rare occurrence."—De Kay, Zoology of New York, 1842.

According to the Natural and Civil History of Vermont, a seal was captured on the ice on Lake Champlain, a little south of Burlington, in February, 1810, and one was killed upon the ice between Burlington and Port Kent, in February, 1846.

"During the past winter one was killed on Onondaga lake that must have reached this remote inland water by way of Lake Ontario.

"I have seen many of these seals in Long Island sound, chiefly about the Thimble islands; and, March 25, 1879, I saw one on a rock in the Hudson river, near Sing Sing."—Merriam, Mammals of the Adirondacks, 1884.

According to newspaper reports one was killed in the Hudson river, at Hyde Park, in the spring of 1893.

NOTE V.—THE HOODED SEAL.

De Kay's description of the hooded seal "was taken from an adult male captured near Eastchester, about fifteen miles from the city (New York). * * * The preceding must be considered as the first notice of its existence within our territorial limits, where it can only be regarded as a rare and accidental visitor."—De Kay, Zoology of New York, 1842.

So far as known this is the only record of the occurrence of the hooded seal in New York.

NOTE VI.—WOLVERINE, GLUTTON, CARCAJOU.

"Although we have not met with this animal, yet hunters who have killed them repeatedly, and knew them well, have assured us that they are still found in the districts north of Racquet lake. It is, however, everywhere a rare species. Prof. Emmons states that they still exist in the Hoosac mountains, Massachusetts. * * * The wolverine was formerly found as far south as Carolina, but its southern limits at present do not extend south of the forty-second degree."—De Kay, Zoology of New York, 1842.

"The wolverine (*Gulo luscus*) is not now an inhabitant of the Adirondacks, and I have been unable to find among the hunters and trappers of this region any one who has ever seen it in our wilderness. * * * Dr. Bachman killed one, about the year 1811, in its den in a ledge of rocks in Rensselaer county.'—Merriam, Mammals of the Adirondacks, 1884.

NOTE VII.—THE WOLF.

The wolf still occurs sparingly in the Adirondacks. Several packs were reported in the newspapers in the winter of 1890–91. The game law of 1892 offers a bounty of thirty dollars for each grown wolf and fifteen dollars for each pup wolf.

NOTE VIII.—THE PANTHER, PUMA, COUGAR.

"A full-grown male panther, weighing 150 pounds, was shot in Stone Lane, within the Schenectady city limits, Saturday afternoon. The animal is thought to have strayed from the Adirondacks."—Albany Press and Knickerbocker, Tuesday, September 5, 1893. The game law of 1892 offers a bounty of twenty dollars for each panther killed in the State.

LAND AND FRESH-WATER SHELLS OF NEW YORK

EXHIBITED AT THE

WORLD'S COLUMBIAN EXPOSITION,

CHICAGO, ILLINOIS.

1893.

Exhibit of New York Land and Fresh-water Shells.

Frederick J. H. Merrill, Ph. D., *Director of the Scientific Exhibit of the State of New York at the World's Columbian Exposition:*

Dear Sir.— I send you herewith a list of the species of Land and Fresh-water Shells of New York exhibited at the World's Columbian Exposition.

The specimens were loaned under proper authority by the New York State Museum, and were derived chiefly from the extensive collections of shells presented to the Museum in 1886 and 1887 by Dr. Charles E. Beecher.

Valuable contributions of specimens were received from the following gentlemen, to whom we return hearty thanks for their courtesy:

Rev. W. M. Beauchamp, Baldwinsville, N. Y.
Mr. Shelley Crump, Pittsford, N. Y.
Mr. T. M. Fry, Syracuse, N. Y.
Mr. W. S. Teator, Upper Red Hook, N. Y.
Mr. Albert Bailey, Chepatchet, N. Y.
Dr. S. Hart Wright, Penn Yan, N. Y.
Mr. James Delaney, Rochester, N. Y.
Prof. George H. Hudson, Plattsburgh, N. Y.
Rev. John Walton, Rochester, N. Y.

Very truly yours.

WILLIAM B. MARSHALL,
Assistant Zoologist, New York State Museum.

Albany, *November* 27, 1893.

I. FRESH-WATER BIVALVES.

Order, Asiphonida,
Class PELECYPODA,
Family UNIONIDÆ,
Genus Unio, *Retzius*.

NAME.	Locality.	Source.
Unio alatus, Say	Genesee river, New York	Pickett Coll.
Unio alatus, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio alatus, Say	Lake Champlain, New York	
Unio gracilis, Barnes	Cross Lake, Onondaga county, N. Y.	Rev. W. M. Beauchamp.
Unio gracilis, Barnes	Erie canal, Rochester, N. Y.	James Delaney.
Unio gracilis, Barnes	Erie canal, Monroe county, N. Y.	Rev. John Walton.
Unio gracilis, Barnes	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio pressus, Lea	Normanskill, Albany, N. Y.	C. E. Beecher.
Unio pressus, Lea	Mannsville, Jefferson county, N. Y.	T. M. Fry.
Unio pressus, Lea	Wellsville, Allegany county, N. Y.	C. E. Beecher.
Unio undulatus, Barnes	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio undulatus, Barnes	Erie canal, Monroe county, N. Y.	Rev. John Walton.
Unio undulatus, Barnes	Erie canal, Monroe county, N. Y.	
Unio perplexus, Lea	Allegany river, near New York boundary *	C. E. Beecher.
Unio verrucosus, Barnes	Allegany river, near New York boundary	C. E. Beecher.
Unio ovatus, Say	Allegany river, near New York boundary	C. E. Beecher.
Unio rubiginosus, Lea	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio rubiginosus, Lea	Genesee river, Monroe county, N. Y.	Rev. John Walton.
Unio rubiginosus, Lea	Erie canal, Onondaga county, N. Y.	Rev. W. M. Beauchamp.
Unio rubiginosus, Lea	Erie canal, Rochester, N. Y.	
Unio rubiginosus, Lea	Genesee canal, Rochester, N. Y.	Pickett Coll.

* All specimens entered in this catalogue as from Allegany river near New York boundary were collected at Warren, Pa., a few miles south of the New York State line.

Unio crassidens, Lamarck	Allegany river, near New York boundary	C. E. Beecher.
Unio clavus, Lamarck	Allegany river, near New York boundary	C. E. Beecher.
Unio patulus, Lea, U clavus, Lam.	Allegany river, near New York boundary	C. E. Beecher.
Unio ellipsis, Lea	Niagara river, Niagara Falls, N. Y	S. M. Luther.
Unio ventricosus, Barnes	Seneca river, Onondaga county, N. Y	C. E. Beecher.
Unio ventricosus, Barnes	Seneca river, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio ventricosus, Barnes	Tonawanda creek, Niagara county, N Y	Dr. S. Hart Wright.
Unio occidens, Lea	Tonawanda creek, Niagara county, N. Y	Dr. S. Hart Wright.
Unio occidens, Lea	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Unio occidens, Lea	Seneca river, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio ochraceus, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Unio ochraceus, Say	Hudson river, Albany, N. Y	C. E Beecher.
Unio cariosus, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Unio cariosus, Say	Hudson river, Albany, N. Y	C. E. Beecher.
Unio cariosus, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Unio multiradiatus, Lea	Genesee river, Monroe county, N. Y	Rev. John Walton.
Unio multiradiatus, Lea	Butternut creek, Otsego county, N. Y.	
Unio multiradiatus, Lea	Medina, Orleans county, N. Y.	Pickett Coll.
Unio multiradiatus, Lea	Allegany river, near New York boundary	C. E. Beecher.
Unio ligamentinus, Lam	Allegany river, near New York boundary	C. E. Beecher.
Unio luteolus, Lam.	New York	Gould collection.
Unio luteolus, Lam.	Genesee river, Monroe county, N. Y	Rev. J. Walton.
Unio luteolus, Lam	Cross lake, Onondaga county, N. Y.	Rev. W. M. Beauchamp.
Unio luteolus, Lam	Ischua creek, Cattaraugus county, N. Y	C. E. Beecher.
Unio luteolus, Lam	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Unio luteolus, Lam	Oswego lake, New York	C. E. Beecher.
Unio luteolus, Lam	Onondaga lake, Syracuse, N. Y	C. E. Beecher.
Unio luteolus, Lam	Genesee river, New York	C. E. Beecher.
Unio rosaceus, unio luteolus, Lam., De Kay	Charlotte, Monroe county, N. Y	Rev. John Walton.
Unio radiatus, Lam	Little lakes, Herkimer county, N. Y	C. E. Beecher.

I. FRESH-WATER BIVALVES — (*Continued*).

NAME.	Locality.	Source.
Unio radiatus, Lam	Normanskill, Albany, N. Y	C. E. Beecher.
Unio radiatus, Lam	Seneca lake, New York	T. M. Fry.
Unio radiatus, Lam	Schuyler's lake, Otsego county, N. Y	C. E. Beecher.
Unio radiatus, Lam	Onondaga lake, New York	C. E. Beecher.
Unio radiatus, Lam	Champlain canal, West Troy, N. Y	C. E. Beecher.
Unio radiatus, Lam	Chenango river, New York	C. E. Beecher.
Unio radiatus. Lam	Tioga river, Steuben county, N. Y	C. E. Beecher.
Unio radiatus, Lam	Little lakes, Herkimer county, N. Y	J. G. Anthony.
Unio radiatus, Lam	Hudson river, Albany, N. Y	C. E. Beecher.
Unio fabalis, Lea	Allegany river, near New York boundary	C. E. Beecher.
Unio parvus, Barnes	Syracuse, N. Y	C. E. Beecher.
Unio parvus, Barnes	Erie canal, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio parvus, Barnes	Genesee canal, Monroe county	Dr. S. Hart Wright.
Unio complanatus, Sol	Champlain canal, West Troy, N. Y	C. E. Beecher.
Unio complanatus, Sol	Hudson river, Albany, N. Y	C. E. Beecher.
Unio complanatus, Sol	Normanskill, Albany, N. Y	C. E. Beecher.
Unio complanatus, Sol	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Unio complanatus, Sol	Lake Luzerne, Warren county, N. Y	C. E. Beecher.
Unio complanatus, Sol	Cortland, N. Y	C. E. Beecher.
Unio complanatus, Sol	Cohocton river, Steuben county, N. Y	C. E. Beecher.
Unio complanatus, Sol	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Unio complanatus, Sol	Mohawk river, Cohoes, N. Y	C. E. Beecher.
Unio complanatus, Sol	Chepatchet creek, Herkimer county, N. Y	C. E. Beecher.
Unio complanatus, Sol	Long lake, Hamilton county, N. Y	C. E. Beecher.
Unio rectus, Lam	Erie canal, Monroe county, N. Y	Rev. John Walton.
Unio rectus, Lam	Pittsford, Monroe county, N. Y	Shelley G. Crump.

Unio rectus, Lam.	Oneida lake, New York	
Unio rectus, Lam.	Seneca river, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio nasutus, Say	Hudson river, Albany, N. Y	C. E. Beecher.
Unio nasutus, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio nasutus, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Unio nasutus, Say	Erie canal, Monroe county, N. Y	Rev. John Walton.
Unio nasutus, Say	Erie canal, Rochester, N. Y.	James Delaney.
Unio Novi-Eboraci, Lea	Erie canal, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio Novi-Eboraci, Lea	Oswego river, New York	
Unio Novi-Eboraci, Lea	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio Novi-Eboraci, Lea	Shenandoah creek, New York	C. E. Beecher.
Unio Novi-Eboraci, Lea	Cayuga lake, New York	C. E. Beecher.
Unio Novi-Eboraci, Lea	Erie canal, Monroe county, N. Y	Rev. John Walton.
Unio phaseolus, Hildreth	Chautauqua lake, New York	C. E. Beecher.
Unio phaseolus, Hildreth	Alleghany river, near New York boundary	C. E. Beecher.
Unio gibbosus, Barnes	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Unio gibbosus, Barnes	Erie canal, Monroe county, N. Y	Rev. John Walton.
Unio gibbosus, Barnes	Allegany river, near New York boundary	C. E. Beecher.
Unio gibbosus, Barnes	Tonawanda creek, Niagara county, N. Y	Dr. S. Hart Wright.
Unio Tappanianus, Lea	Erie canal, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Unio Tappanianus, Lea	Erie canal, Mohawk, N. Y	Rev. James Lewis.
Unio Tappanianus, Lea	Erie canal, Mohawk, N. Y	C. E. Beecher.
Unio Tappanianus, Lea	Erie canal, West Troy, N. Y	T. H. Aldrich.
Unio Tappanianus, Lea	Hudson river, Troy, N. Y	T. H. Aldrich.
Unio Tappanianus, Lea	Erie canal, Mohawk, N. Y.	

Genus Margaritana, *Schumacher.*

Margaritana marginata, Say	Mohawk river, New York	C. E. Beecher.
Margaritana marginata, Say	Mohawk river, Cohoes, N. Y	C. E. Beecher.
Margaritana marginata, Say	Seneca river, New York	C. E. Beecher.

I. FRESH-WATER BIVALVES — (*Continued*).

NAME.	Locality.	Source.
Margaritana marginata, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Margaritana marginata, Say	Erie canal, New York	C. E. Beecher.
Margaritana marginata, Say	New York	
Margaritana marginata, Say	Manlius, Onondaga county, N. Y.	
Margaritana rugosa, Barnes	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Margaritana rugosa, Barnes	Mohawk river, Cohoes, N. Y.	C. E. Beecher.
Margaritana rugosa, Barnes	Hudson river, Cohoes, N. Y.	
Margaritana rugosa, Barnes	Hudson river, Albany, N. Y.	C. E. Beecher.
Margaritana rugosa, Barnes	Onondaga lake, New York	C. E. Beecher.
Margaritana rugosa, Barnes	Cross lake, Onondaga county, N. Y.	Rev. W. M. Beauchamp.
Margaritana rugosa, Barnes	Genesee canal, Olean, N. Y.	C. E. Beecher.
Margaritana rugosa, Barnes	Normanskill, Albany, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Normanskill, Albany, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Chepatchet creek, Herkimer county, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Canisteo river, Steuben county, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Herkimer county, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Beaver lake, Herkimer county, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Chenango river, New York	C. E. Beecher.
Margaritana undulata, Say	Cohocton river, Steuben county, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Margaritana undulata, Say	Madison county, N. Y.	C. E. Beecher.
Margaritana deltoidea, Lea	Erie canal, Monroe county, N. Y.	Rev. John Walton.
Margaritana deltoidea	Mud creek, New York	James Delaney.
Margaritana margaritifera, Linn.	Lake Champlain, New York	Gould collection.

Genus Anodanta, *Cuvier.*

Anodonta fragilis, Lam.	Beaver lake, Onondaga county, N. Y.	Rev. W. M. Beauchamp.
Anodonta fragilis, Lam.	Beaver lake, Onondaga county, N. Y.	C. E. Beecher.
Anodonta fragilis, Lam.	Otsego lake, New York	C. E. Beecher.
Anodonta fragilis, Lam.	Cayuga lake, New York	
Anodonta fragilis, Lam.	Keuka lake, New York	Dr. S. Hart Wright.
Anodonta Benedictii, Lea	Onondaga lake, New York	Rev. W. M. Beauchamp.
Anodonto Benedictii, Lea	Erie canal, Rochester, N. Y.	Rev. John Walton.
Anodonta Benedictii, Lea	Lake Champlain, New York	George H. Hudson.
Anodonta Benedictii, Lea	New York	Emmons collection.
Anodonta Footiana, Lea	Canandaigua lake, New York	Pickett collection.
Anodonta edentula, Say	Ischua creek, Cattaraugus county, N. Y.	C. E. Beecher.
Anodonta edentula, Say	Chautauqua lake, New York	C. E. Beecher.
Anodonta edentula, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Anodonta edentula, Say	Seneca river, New York	C. E. Beecher.
Anodonta edentula, Say	Genesee river, Monroe county, N. Y.	Rev. John Walton.
Anodonta edentula, Say	Erie canal, Monroe county, N. Y.	Rev. John Walton.
Anodonta edentula, Say	Honeoye creek, Monroe county, N. Y.	James Delaney.
Anodonta undulata, Say	Normanskill, Albany, N. Y.	C. E. Beecher.
Anodonta undulata, Say	Normanskill, Albany, N. Y.	
Anodonta implicata, Say	Erie canal, West Troy, N. Y.	C. E. Beecher.
Anodonta implicata, Say	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw.	Dover Plains, Dutchess county, N. Y.	W. S. Teator.
Anodonta fluviatilis, Dillw.	Normanskill, Albany, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw.	Ischua creek, Cattaraugus county, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	Buffalo creek, Erie county, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	Andover, Allegany county, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	Farnum's pond, Troy, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	Champlain canal, West Troy, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	West Mission, Steuben county, N. Y.	C. E. Beecher.
Anodonta fluviatilis, Dillw	Genesee canal, Allegany county, N. Y.	C. E. Beecher.

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I. FRESH-WATER BIVALVES — (*Concluded*).

NAME.	Locality.	Source.
Anodonta fluviatilis, Dillw	Erie canal, West Troy, N. Y	C. E. Beecher.
Anodonta fluviatilis, Dillw	Black Rock pond, Albany county, N. Y	C. E. Beecher.
Anodonta fluviatilis, Dillw	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Anodonta fluviatilis, Dillw	Mohawk basin, West Troy, N. Y	C. E Beecher.
Anodonta Lewisii, Lea	Erie canal, Herkimer county, N. Y	Dr. James Lewis.
Anodonta Lewisii, Lea	Normanskill, Albany, N. Y	C. E. Beecher.
Anodonta Lewisii, Lea	Erie canal, New York	C. E. Beecher.
Anodonta Lewisii, Lea	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Anodonta lacustris, Lea	Canisteo river, Steuben county, N. Y	C. E. Beecher.
Anodonta lacustris, Lea	Cedar lake, Herkimer county, N. Y	C. E. Beecher.
Anodonta lacustris, Lea	Little Lakes, Herkimer county, N. Y	C. E. Beecher.
An. subcylindracea, Lea = A. Ferussaciana, Lea.	Normanskill, Albany, N. Y	C. E. Beecher.
An. subcylindracea, Lea = A. Ferussaciana, Lea.	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Anodonta Ferussaciana, Lea	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Anodonta subcylindracea, Lea = A. Ferussaciana, Lea.	Nine-mile creek, Onondaga county, N. Y	C. E. Beecher.
Anodonta subcylindracea, Lea = A. Ferussaciana, Lea.	Erie canal, New York	C. E. Beecher.
Anodonta Ferussaciana, Lea	Erie canal, Rochester, N. Y	Rev. J. Walton.
Anodonta Ferussaciana, Lea	Keuka lake, Yates county, N. Y	Dr. S. Hart Wright.
Anodonta Ferussaciana, Lea	Honeoye creek, Monroe county, N. Y	James Delaney.
Anodonta Ferussaciana, Lea	Erie canal, Syracuse, N. Y	James Delaney.

Order Siphonida,

Family Cyrenidæ,

Genus Sphærium. *Scopoli.*

Sphærium simile, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Sphærium simile, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Sphærium occidentalis, Prime	Cedar Lake, Herkimer county, N. Y	C. E. Beecher.
Sphærium striatinum	Normanskill, Albany, N. Y	
Sphærium rhomboideum, Say	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Sphærium occidentale, Prime	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Sphærium rosaceum, Prime	Mohawk, Herkimer county, N. Y	Dr. James Lewis.
Sphærium partumeium, Say	Astoria, Long Island, N. Y.	Temple Prime.
Sphærium truncatum, Lins	New York	Dr. James Lewis.
Sphærium transversum, Say	Normanskill, Albany, N. Y	
Sphærium secure, Prime	New York	

Genus Pisidium. *Pfeiffer.*

Pisidium æquilaterale, Prime	Cedarville, Herkimer county, N. Y	C. E Beecher.
Pisidium ventricosum, Prime	New York	Dr. James Lewis.
Pisidium abditum, Prime	Long Island, N. Y	Temple Prime.
Pisidium Virginicum, Bourg	Hudson river, Albany, N. Y	C. E. Beecher.
Pisidium compressum, Prime	New York	Dr. James Lewis.
Pisidium compressum, Prime	Mohawk river, New York	C. E. Beecher.
Pisidium ferrugineum, Prime	New York	Dr. James Lewis.

II. FRESH-WATER UNIVALVES.

Class Gasteropoda,
Order PECTINIBRANCHIATA,
Family STREPOMATIDÆ,
Genus Goniobasis. *Lea.*

NAME.	Locality.	Source.
Goniobasis Virginica, Gmel	Hudson river, Albany, N. Y	C. E. Beecher.
Goniobasis Virginica, Gmel (immature)	Normanskill, Albany, N. Y	C. E. Beecher.
Goniobasis Virginica, Gmel., var. multilineate, Say	Hudson river, Albany, N. Y	C. E. Beecher.
Goniobasis Virginica, Gmel	Erie canal, Monroe county, N. Y	Rev. J. Walton.
Goniobasis depygis, Say	Baldwinsville, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Goniobasis livescens, Menke	Erie canal, New York	
Goniobasis livescens, Menke	Erie canal, West Troy, N. Y	T. H. Aldrich.
Goniobasis livescens, Menke	Mohawk river, Cohoes, N. Y	C. E. Beecher.

Genus Pleurocera, *Rafinesque.*

NAME.	Locality.	Source.
Pleurocera subulare, Lea	Erie canal, New York	
Pleurocera subulare, Lea	Mohawk river, New York	T. H. Aldrich.
Pleurocera subulare, Lea	Monroe county, N. Y	Rev. John Walton.
Pleurocera subulare, Lea	Lake Ontario, Monroe county, N. Y	Rev. John Walton.

Genus Anculosa, *Say.*

NAME.	Locality.	Source.
Anculosa carinata, Brug	Susquehanna river, New York	
Anculosa carinata, Brug	Chemung river, New York	C. E. Beecher.
Anculosa carinata, Brug	Cortland, N. Y	C. E. Beecher.

Family RISSOIDÆ,

	Genus Bythinia, *Gray.*	
Bythinia tentaculata, Linn	Erie canal, West Troy, N. Y	C. E. Beecher.
	Genus Bythinella, *Moquin-Tandon.*	
Bythinella obtusa, Lea	Mohawk river, Mohawk, N. Y	Dr. James Lewis.
Bythinella obtusa, Lea	Onondaga county, N. Y	Rev. W. M. Beauchamp.
	Genus Gillia, *Stimpson.*	
Gillia altilis, Lea	Hudson river, Albany county, N. Y	C. E. Beecher.
	Genus Somatogyrus, *Gill.*	
Somatogyrus subglobosus, Say	Erie canal, Mohawk, N. Y	T. H. Aldrich.
	Genus Amnicola, *Gould & Haldeman.*	
Amnicola Sayana, Anth	Ontario county, N. Y	J. M. Clarke.
Amnicola porata, Say	Mohawk river, Cohoes, N. Y	C. E. Beecher.
Amnicola porata, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Amnicola pallida, Hald	Mohawk river, Mohawk, N. Y	C. E. Beecher.
Amnicola pallida, Anth	Normanskill, Albany, N. Y	C. E. Beecher.
Amnicola pallida, Anth	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Amnicola Cincinnatiensis, Anth	Erie canal, Mohawk, N. Y	T. H. Aldrich.
Amnicola limosa, Say	Erie canal, Mohawk, N. Y	Dr. James Lewis.
	Genus Pomatiopsis, *Tryon.*	
Pomatiopsis lapidaria, Say	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Pomatiopsis lustrica, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Pomatiopsis lustrica, Say	Erie canal, Mohawk, N. Y	Dr. James Lewis.

II. FRESH-WATER UNIVALVES — (*Continued*).

Family VALVATIDÆ.

Genus Valvata, *Muller*.

NAME.	Locality.	Source.
Valvata sincera, Say	Winfield, Herkimer county, N. Y.	Albert Bailey.
Valvata tricarinata, Say, var. simplex.	Little Lakes, Herkimer county, N. Y	C. E. Beecher.
Valvata tricarinata, Say	Schuyler's Lake, Otsego county, N. Y.	C. E. Beecher.
Valvata tricarinata, Say	Hudson river, Albany, N. Y	C. E. Beecher.
"Valvata arenifera," Lea = larva case of the insect Phryganía	Oneida river, Onondaga county, N. Y	Rev. W. M. Beauchamp.

Family VIVIPARIDÆ.

Genus Vivipara, *Lamarck*.

NAME.	Locality.	Source.
Vivipara contectoides,* W. G. Binn	Erie canal, New York	C. E. Beecher.
Vivipara contectoides, W. G. Binn (Embryos)	Erie canal, Albany, N. Y	W. B. Marshall.
Vivipara contectoides, W. G. Binn	Erie canal, Mohawk, N. Y	Dr. James Lewis.

Genus Melantho, *Bowditch*.

NAME.	Locality.	Source.
Melantho rufa, Hald. = M. decisa, Say.	Normanskill, Albany, N. Y.	C. E. Beecher.
Melantho rufa, Hald. = M. decisa, Say.	Erie canal, New York	C. E. Beecher.
Melantho rufa, Hald. = M. decisa, Say.	Erie canal, Mohawk, N. Y	C. E. Beecher.
Melantho integra, Say = M. decisa, Say	Champlain canal, West Troy, N. Y	C. E Beecher.
Melantho integra, Say = M. decisa, Say	Erie canal, Mohawk, N. Y	C. E. Beecher.
Melantho integra, Say = M. decisa, Say	Erie canal, Herkimer county, N. Y	Dr. James Lewis.
Melantho decisa, Say	Schuyler's Lake, Otsego county, N. Y.	C. E. Beecher.

* Vivipara contectoides was colonized in the Erie canal by Dr. James Lewis.

Genus Lioplax, *Troschel.*

Lioplax subcarinata, Say	Normanskill, Albany, N. Y	C. E. Beecher.

Order Pulmonata.

Suborder Limnophila.

Family Auriculidæ.

Genus Alexia, *Gray.*

Alexia myosotis, Drap	New York	
Alexia myosotis, Drap	Huntington, Long Island, N. Y	Temple Prime.

Genus Carychium, *Muller.*

Carychium exiguum, Mull	Litchfield, Herkimer county, N. Y	C. E. Beecher.

Genus Melampus, *Montfort.*

Melampus bidentatus, Say	Grassmere, Staten Island, N. Y	A. H. Gardner.
Melampus bidentatus, Say	Coney Island, N. Y	T. H. Aldrich.

Family Limnæidæ.

Subfamily Limnæinæ.

Genus Limnæa, *Lamarck.*

Limnæa stagnalis, Linn	Leroy, Genesee county, N. Y	C. E. Beecher.
Limnæa stagnalis, Linn	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Limnæa stagnalis, Linn	Erie Canal, Rochester, N. Y	

Subgenus Bulimnea, *Haldeman.*

Limnæa megasoma, Hald	Lake Champlain, New York	George H. Hudson (loaned).

II. Fresh-Water Univalves — (*Continued*).

Subgenus Radix, *Montfort.*

NAME.	Locality.	Source.
Limnæa columella, Say	Fort Hamilton, Long Island, N. Y	A. H. Gardner.
Limnæa columella, Say	New York	
Limnæa columella, Say	Seneca river, New York	C. E. Beecher.
Limnæa columella, Say	Little Lakes, Herkimer county, N. Y	C. E. Beecher.
Subgenus Limnophysa, *Fitz.*		
Limnæa reflexa, Say	Lake Erie	C. E. Beecher.
Limnæa reflexa, Say	Erie canal, Rochester, N. Y	Rev. John Walton.
Limnæa reflexa, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Limnæa elodes, Say	Jefferson county, New York	Rev. John Walton.
Limnæa elodes, Say	Rochester, N. Y	C. E. Beecher.
Limnæa elodes, Say	New York	
Limnæa elodes, Say	Suspension Bridge, Niagara county, N. Y	C. E. Beecher.
Limnæa desidiosa, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Limnæa desidiosa, Say	Albany, N. Y	C. E. Beecher.
Limnæa (Sp?)	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Limnæa catascopium, Say	Mohawk river, New York	T. H. Aldrich.
Limnæa catascopium, Say	Hudson river, Albany, N. Y	C. E. Beecher.
Limnæa catascopium, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Limnæa catascopium, Say (Amplified variety)	Erie canal, New York	Dr. James Lewis.
Limnæa catascopium, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Limnæa pallida, Adams	Cross lake, Onondaga county	Rev. W. M. Beauchamp.
Limnæa pallida, Adams	Pittsford, Monroe county, N. Y	Shelley G. Crump.

Limnæa emarginata, Say	Oswego, N. Y	Rev. W. M. Beauchamp.
Limnæa caperata, Say	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Limnæa humilis, Say	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Limnæa humilis, Say	Winfield, Herkimer county, N. Y.	Albert Bailey.
	Subgenus Acella, *Haldeman.*	
Limnæa gracilis, Jay	Buffalo, N. Y	Buff. Soc. Nat. Sci.
	Genus Physa, *Draparnaud.*	
Physa gyrina, Say	Erie canal, Monroe county, N. Y	Rev. John Walton.
Physa gyrina, Say	Baldwinsville, Onondaga county, N. Y	Rev. W. M. Beauchamp.
Physa ancillaria, Say	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Physa heterostropha, Say	New York	
Physa heterostropha, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Physa heterostropha, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Physa heterostropha, Say	Glen Cove, Long Island, N. Y.	A. H. Gardner.
Physa heterostropha, Say	New Dorp, Staten Island, N. Y.	A. H. Gardner.
Physa integer, Hald	Little Lakes, Herkimer county, N. Y	C. E. Beecher.
Physa integer, Hald	Erie canal, New York	C. E. Beecher.
	Genus Bulinus, *Adanson.*	
Bulinus hypnorum, Linn.	West Albany, N. Y.	C. E. Beecher.
Bulinus hypnorum, Linn.	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Bulinus hypnorum, Linn.	Winfield, Herkimer county, N. Y.	Albert Bailey.
	Subfamily PLANORBINÆ.	
	Genus Planorbis, *Guettard.*	
	Subgenus Planoebella, *Haldeman.*	
Planorbis campanulatus	Cedar Lake, Herkimer county, N. Y	C. E. Beecher.
Planorbis campanulatus, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.

II. Fresh-Water Univalves — (*Continued*).

Subgenus Helisoma, *Swainson.*

NAME.	Locality.	Source.
Planorbis trivolvis, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Planorbis trivolvis, Say	Cortland, N. Y	C. E. Beecher.
Planorbis trivolvis, Say	Greenbush, Rensselaer county, N. Y	C. E Beecher.
Planorbis trivolvis, Say	Onondaga lake, N. Y	C. E. Beecher.
Planorbis bicarinatus, Say	Cedar lake, Herkimer county, N. Y	C. E. Beecher.
Planorbis bicarinatus, Say	Albany, N. Y	C. E. Beecher
Planorbis bicarinatus, Say	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Subgenus Menetus, *H. & A. Adams.*		
Planorbis exacutus, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Planorbis exacutus, Say	Cedar lake, Herkimer county, N. Y	C. E. Beecher.
Subgenus Gyraulus, *Agassiz.*		
Planorbis deflectus, Say	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Planorbis deflectus, Say	Erie canal, Monroe county, N. Y	Rev. John Walton.
Planorbis hirsutus, Gould	Little Lakes, Herkimer county, N. Y	C. E. Beecher.
Planorbis hirsutus, Gould	Seneca river, N. Y	Rev. John Walton.
Planorbis parvus, Say	Normanskill, Albany, N. Y	C. E. Beecher.
Planorbis parvus, Say	Mohawk river, Cohoes, N. Y	C. E. Beecher.
Genus Segmentina, *Fleming.*		
Segmentina armigera, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Segmentina armigera, Say	Sand lake, N. Y	....

Subfamily ANCYLINÆ.

Genus Ancylus, *Geoffroy.*

Ancylus fuscus, Adams	Normanskill, Albany, N. Y	C. E. Beecher.
Ancylus parallelus, Hald.	Little Lakes, Herkimer county, N. Y	Dr. James Lewis.
Ancylus parallelus, Hald.	Normanskill, Albany, N. Y	C. E. Beecher.
Ancylus tardus, Say	Mohawk river, Mohawk, N. Y	Dr. James Lewis.
Ancylus rivularis, Say	Ontario county, N. Y	J. M. Clarke.

Genus Gundlachia, *Pfeiffer.*

Gundlachia Meekiana, Stimp	Canandaigua, Ontario county, N. Y	J. M. Clarke.

III. LAND SHELLS.

Suborder **Geophila.**

Family SELENITIDÆ.

Genus Macrocyclis, *Beck.*

NAME.	Locality.	Source.
Macrocyclis concava, Say	Pittsford, Monroe county, N. Y.	Rev. John Walton.
Macrocyclis concava, Say	New York	Dr. James Lewis.
Macrocyclis concava, Say	Winfield, Herkimer county, N. Y.	Albert Bailey.
Macrocyclis concava, Litchfield	Herkimer county, N. Y	C. E. Beecher.
Macrocyclis concava, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Family LIMACIDÆ.		
Genus Limax, *Linnæus.*		
Limax maximus, Linn	Introduced from Europe. (Drawing exhibited)	
Limax flavus, Linn	Introduced from Europe. (Drawing exhibited)	
Limax campestris, Binn		
Limax agrestis, Linn	Introduced from Europe. (Drawing exhibited)	
Genus Zonites, *Montfort.*		
Subgenus Mesomphix, *Rafinesque.*		
Zonites fuliginosus, Griff	Rochester, N. Y	James Delaney.
Zonites fuliginosus, Griff	Winfield, Herkimer county, N. Y	Albert Bailey.
Zonites fuliginosus, Griff	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Zonites fuliginosus, Griff	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Zonites inornatus, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Zonites inornatus, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Zonites ligerus, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.

Zonites intertextus, Binn	Ontario county, N. Y	J. M. Clarke.
Zonites intertextus, Binn	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Zonites intertextus, Binn	Pittsford, Monroe county, N. Y	Shelley G. Crump.

Subgenus Hyalinia, *Agassiz.*

Zonites cellarius, Mull	Astoria, Long Island, N. Y	Temple Prime.
Zonites nitidus, Mull	Ilion, Herkimer county, N. Y	C. E. Beecher.
Zonites arboreus, Say	Pittsford, Monroe county, N. Y	Rev. John Walton.
Zonites arboreus, Say	Greenbush, Rennselaer county, N. Y	C. E. Beecher.
Zonites arboreus, Say	Troy, N. Y	T. H. Aldrich.
Zonites viridulus, Menke	Silver Lake, Staten Island, N. Y	A. H Gardner.
Zonites viridulus, Menke	Pittsford, Monroe county, N. Y	Rev. John Walton.
Zonites viridulus, Menke	Troy, N. Y	T. H. Aldrich.
Zonites indentatus, Say	New Dorp, Staten Island, N. Y	A. H. Gardner.
Zonites indentatus, Say	Genesee county, N. Y	Rev. John Walton.
Zonites indentatus, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Zonites indentatus, Say	Huntington, Long Island, N. Y	Temple Prime.
Zonites minusculus	Binn., Fort Hamilton, Long Island, N. Y	A. H. Gardner.
Zonites Binneyanus, Morse	Huntington, Long Island, N. Y.	Temple Prime.
Zonites ferreus, Morse	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Zonites exiguus, Stimp	Monroe county, N. Y.	Rev. John Walton.
Zonites exiguus, Stimp	Litchfield, Herkimer county, N. Y	C. E. Beecher.

Subgenus Conulus, *Moquin-Tandon.*

Zonites fulvus, Drap	Litchfield, Herkimer county, N. Y	C. E. Beecher.

Subgenus Gastrodonta, *Albers.*

Zonites internus, Say	Albany, N. Y	T. H. Aldrich.
Zonites multidentatus, Binn	Baldwinsville, Onondaga county, N. Y	C. E. Beecher.
Zonites multidentatus, Binn	Litchfield, Herkimer county, N. Y	C. E. Beecher.

III. Land Shells — (*Continued*).

Genus Vitrina, *Draparnaud.*

NAME.	Locality.	Source.
Vitrina limpida, Gould	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Vitrina limpida, Gould	Litchfield, Herkimer county, N. Y	Dr. James Lewis.
Vitrina limpida, Gould	Winfield, Herkimer county, N. Y	Albert Bailey.
Family Philomycidæ,		
Genus Tebennophorus, *Binney.*		
Tebennophorus Carolinensis, Bosc	(Drawing exhibited)	
Tebennophorus dorsalis, Binn	(Drawing exhibited)	
Family Helicidæ,		
Genus Helix, *Linnæus,*		
Section Patula, *Haldeman.*		
Patula alternata, Say	Albany, N. Y	C. E. Beecher.
Patula alternata, Say	Pittsford, Monroe county, N. Y	Rev. John Walton.
Patula alternata, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Patula perspectiva, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Patula perspectiva, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Patula perspectiva, Say	Winfield, Herkimer county, N. Y	Albert Bailey.
Patula striatella, Anth	Pittsford, Monroe county, N. Y	Rev. John Walton.
Patula striatella, Anth	Greenbush, Rensselaer county, N. Y	C. E. Beecher.
Patula striatella, Anth	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Patula striatella, Anth	Winfield, Herkimer county, N. Y	Albert Bailey.

Section MICROPHYSA, *Albers.*		
Microphysa pygmæa, Darp	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Section HELICODISCUS, *Morse.*		
Helicodiscus lineatus, Say	Pittsford, Monroe county, N. Y	Rev. John Walton.
Helicodiscus lineatus, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Section STROBILA, *Morse.*		
Strobila labyrinthica, Say	Staten Island, N. Y	E. W. Hubbard.
Section STENOTREMA, *Rafinesque.*		
Stenotrema hirsutum, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Stenotrema hirsutum, Say	Pittsford, Monroe county, N. Y	
Stenotrema monodon, Rack	Albany, N. Y	C. E. Beecher.
Stenotrema monodon, Rack	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Section VALLONIA, *Risso.*		
Vallonia pulchella, Mull	Pittsford, Monroe county, N. Y	Rev. John Walton.
Vallonia pulchella, Mull.	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Vallonia pulchella, Mull	Ontario county, N. Y	J.M. Clarke.
Section TRIODOPSIS, *Rafinesque.*		
Triodopsis palliata, Say	Pittsford, Monroe county, N. Y	Rev. John Walton.
Triodopsis palliata, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Triodopsis palliata, Say	Winfield, Herkimer county, N. Y	Albert Bailey.
Triodopsis palliata, Say	Annandale, Dutchess county, N. Y	W. S. Teator.
Triodopsis appressa, Say		Dr. James Lewis.
Triodopsis appressa, Say	Albany, N. Y	T. H. Aldrich.
Triodopsis inflecta, Say	Albany, N. Y	T. H. Aldrich.
Triodopsis fallax, Say	Ohio	C. E. Beecher.

III. LAND SHELLS — (*Continued*).

NAME.	Locality.	Source.
Triodopsis fallax, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Triodopsis tridentata Say	High bridge, New York city	A. H. Gardner.
Triodopsis tridentata, Say	New York.	
Triodopsis tridentata, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Triodopsis tridentata, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
	Section MESODON, *Rafinesque.*	
Mesodon albolabris, Say	Annandale, Dutchess county, N. Y	W. S. Teator.
Mesodon albolabris, Say	Albany, N. Y	C. E. Beecher.
Mesodon albolabris, Say	Cedarville, Herkimer county, N. Y	C. E. Beecher.
Mesodon albolabris, Say	Herkimer county, N. Y.	Dr. James Lewis.
Mesodon albolabris, Say	Winfield, Herkimer county, N. Y.	Albert Bailey.
Mesodon albolabris, Say	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Mesodon albolabris, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Mesodon Mitchellianus, Lea	Litchfield, Herkimer county, N. Y	Albert Bailey.
Mesodon elevatus, Say	Litchfield, Herkimer county, N. Y.	Albert Bailey.
Mesodon exoletus, Binn.	Litchfield, Herkimer county, N. Y	Albert Bailey.
Mesodon dentiferus, Binn	West Winfield, Herkimer county, N. Y	C. E. Beecher.
Mesodon dentiferus, Binn.	Litchfield, Herkimer county, N. Y.	Albert Bailey.
Mesodon multilineatus, Say	Ann Harbor, Michigan	C. E. Beecher.
Mesodon profundus, Say	Litchfield, Herkimer county, N. Y.	Albert Bailey.
Mesodon thyroides, Say	Rochester, N. Y.	Rev. John Walton.
Mesodon thyroides, Say	Pittsford, Monroe county, N. Y	Shelley G. Crump.
Mesodon thyroides, Say	Pittsford, Monroe county, N. Y.	
Mesodon thyroides, Say	Elizaville, Columbia county, N. Y.	W. S. Teator.

Mesodon bucculenta, Gould, = M. thyroides, Say	Long Island, N. Y	T. H. Aldrich.
Mesodon thyroides, Say	Annandale, Dutchess county, N. Y	W. S. Teator,
Mesodon Sayii, Binn	Mohawk, Herkimer county, N. Y	C. E .Beecher.
Mesodon Sayii, Binn	Albany, N. Y	C. E. Beecher.
Mesodon Sayii, Binn	Monroe county, N. Y	Shelley G. Crump.
Mesodon Sayii, Binn	Winfield, Herkimer county, N. Y	Albert Bailey.
Mesodon Sayii, Binn	Herkimer county, N. Y	Dr. James Lewis.

Family Pupidæ.

Genus Pupa, *Draparnaud.*

Subgenus Pupilla. *Leach.*

Pupa muscorum, Linn	Crown Point, Essex county, N. Y	Gould collection.
Pupa muscorum, Linn	Auburn, Cayuga county, N. Y	Gould collection.
Pupa muscorum, Linn	Rochester, N. Y	Rev. W. M. Beauchamp.
Pupa muscorum, Linn	Rochester, N. Y	James Delaney.
Pupa muscorum, Linn.		
Pupa pentodon, Say	Jefferson county, N. Y	T. M. Fry.
Pupa pentodon, Say	Long Island, N. Y	Temple Prime.

Subgenus Leucochila, *Alb. and Mart.*

Pupa armifera, Say	Meadowdale, Albany county, N. Y	W. B. Marshall.
Pupa armifera, Say	Yates county, N. Y	T. M. Fry.
Pupa contracta, Say	Litchfield, Herkimer county, N. Y	C. E. Beecher.
Pupa fallax, Say	Coldspring, Long Island, N Y	Temple Prime.
Pupa fallax, Say	Clarksville, Albany county, N. Y	C. E. Beecher.
Pupa curvidens, Gould	Meadowdale, Albany county, N. Y	W. B. Marshall.
Pupa contracta, Say	Fort Hamilton, Long Island, N. Y	A. H. Gardner.

III. LAND SHELLS — (*Continuea*).

NAME.	Locality.	Source.
Pupa corticaria, Say	Albany, N. Y.	C E. Beecher.
Pupa corticaria, Say	Meadowdale, Albany county, N Y.	W. B. Marshall.
Pupa corticaria, Say	Ontario county, N. Y	J. M. Clarke.
Pupa rupicola, Say		Gould collection.
	Genus Vertigo, *Muller*.	
	Subgenus Isthmia, *Gray*.	
Vertigo Gouldii, Binn.	Albany, N. Y.	C. E. Beecher.
Vertigo simplex, Gould	Ontario county, N. Y	J. M. Clarke.
Vertigo Bollesiana, Morse	Meadowdale, Albany county, N. Y	W. B. Marshall.
Vertigo milium, Gould	Long Island, N. Y.	Temple Prime.
Vertigo ovata, Say	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Vertigo pygmæa, Drap.	Fort Hamilton, Long Island, N. Y.	A. H. Gardner.
	Family Stenogyridæ.	
	Genus Ferussacia, *Risso*.	
Ferussacia subcylindrica, Linn.	Rochester, N. Y.	Rev. John Walton.
Ferussacia subcylindrica, Linn.	Fort Wadsworth, Staten Island, N. Y.	A. H. Gardner.
Ferussacia subcylindrica, Linn.	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
	Family Succinea.	
	Genus Succinea, *Draparnaud*.	
Succinea ovalis, Gould	Litchfield, Herkimer county, N. Y.	C. E. Beecher.
Succinea ovalis, Gould	Albany, N. Y.	C. E. Beecher.

Succinea ovalis, Gould	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Succinea obliqua, Say	Annandale, Dutchess county, N. Y	W. S. Teator.
Succinea obliqua, Say	Mohawk, Herkimer county, N. Y.	C. E. Beecher.
Succinea obliqua, Say	Albany, N. Y.	C. E. Beecher.
Succinea obliqua, Say	Frankfort, Herkimer county, N. Y	C. E. Beecher.
Succinea obliqua, Say	Upper Red Hook, Dutchess county, N. Y	W. S. Teator.
Succinea obliqua, Say	Pittsford, Monroe county, N. Y.	Shelley G. Crump.
Succinea obliqua, Say	Winfield, Herkimer county, N. Y.	Shelley G. Crump.
Succinea obliqua, Say	Pittsford, Monroe county, N. Y.	Rev. John Walton.
Succinea avara, Say	Albany, N. Y.	C. E. Beecher.
Succinea avara, Say	Fort Washington, New York city	W. S. Teator.

CATALOGUE

OF THE

Marginellidæ, Olividæ, Columbellidæ, Conidæ, Terebridæ, Cancellariidæ, Strombidæ, Cypræidæ, Ovulidæ, Cassididæ and Doliidæ Contained in the Collections of the New York State Museum — Exclusive of the Mazatlan Collection.

FAMILY MARGINELLIDÆ.

NAME.	Locality.	Collection.	Specimens.
Genus Erato, Risso.			
Erato lævis, Donov	Great Britain	Smithsonian	1
Erato leucophæ, Gould=E. columbella, Mke	Santa Barbara, Cal	Gould	(Types) 2
Subgenus Eratopsis, Hoernes and Auinger.			
Erato scabriuscula, Gray	Acapulco	Smithsonian	1
Erato corrugata, Hinds	China Sea	Gould	1
Genus Marginella, Lamarck.			
Marginella glabella, Linn		Gould	3
Marginella glabella, Linn		H. Cuming	1
Marginella labiata, Val	Africa (?)	Gould	3
Marginella labiata, Val		Gould	1
Marginella helmatina, Rang		Gould	1
Section Glabella, Swainson.			
Marginella bifasciata, Lam.		Gould	1
Marginella Adansoni, Kien		Gould	4
Marginella Cleryi, Petit	Senegal	Gould	1
Marginella formicula, Lam	Australia	Gould	2
Marginella hæmatita, Kien		Gould	1
Section Prunum (Martini), Adams.			
Marginella marginata, Born	Africa		2
Marginella marginata, Born		Gould	42
Marginella curta, Sowb		Gould	3

FAMILY MARGINELLIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Prunum (Martini), Adams — (*Concluded*).			
Marginella prunum, Gmel	Cumana, Venez.	Gould	6
Marginella prunum, Gmel	Panama	Gould	5
Marginella prunum, Gmel	Panama		3
Marginella prunum, Gmel	Panama	H. Cumming	1
Marginella prunum, Gmel		Gould	10
Section Cryptospira, Hinds.			
Marginella quinqueplicata, Lam	Burmah	Gould	5
Marginella quinqueplicata, Lam., var. Hainesii, Petit.		Gould	3
Marginella quinqueplicata, Lam., var. Hainesii, Petit.		H. Cumming	1
Marginella elegans, Gmel		Gould	3
Marginella guttata, Dillw		Gould	13
Marginella guttata, Dillw	Key West	F. J. H. Merrill	6
Marginella carnea, Kien		Gould	8
Marginella apicina, Mke		Gould	263
Marginella apicina, Mke	Bahama Is.	Gould	41
Marginella apicina, Mke			11
Marginella apicina, Mke	West Indies		6
Marginella pellucida, Pfr.		Gould	11
Section Volutella, Swainson.			
Marginella bullata, Born.		Gould	1
Marginella angustata, Sowb.	Brazil	Gould	1

Section Persicula, Schumacher.			
Marginella cornea, Lam.		H. Cuming	1
Marginella cornea, Lam.	Gambia, W. Africa	Smithsonian	1
Marginella cornea, Lam.		Gould	8
Marginella persicula, Linn		Gould	7
Marginella persicula, Linn			1
Marginella cingulata, Dillw.		H. Cuming	1
Marginella cingulata, Dillw.		Gould	4
Marginella porcellana, Gmel.		Gould	13
Marginella interruptelineata, Muhlf			3
Marginella interruptelineata, Muhlf		Gould	28
Marginella interruptelineata, Muhlf	Isle of France		2
Marginella interruptelineata, Muhlf	West Africa	Gould	7
Marginella interruptelineata, Muhlf	West Indies	F. J. H. Merrill	42
Marginella imbricata, Hinds.		Gould	3
Marginella imbricata, Hinds.	California	Gould	5
Marginella maculosa, Kien	West Indies	Gould	1
Marginella phrygia, Sowb.	Mazatlan	Gould	4
Marginella phrygia, Sowb.	C. St Lucas		1
Marginella catenata, Mont		Gould	10
Marginella chrysomelina, Redf	West Indies	Gould	8
Marginella oryza, Lam.		Gould	3
Marginella Guancha, d'Orb.	Canary Is.		1
Section Gibberula, Swainson.			
Marginella monilis, Linn.	C. Good Hope	Gould	3
Marginella monilis, Linn.		Gould	4–1
Marginella miliaria, Linn	Canary Is.		27
Marginella Jewettii, Carp.	Santa Barbara	Gould	1
Marginella regularis, Carp	Santa Barbara	Smithsonian	1
Marginella minuta, Pfr.	Villafranca		1

FAMILY MARGINELLIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Subgenus Volvaria, Lam.			
Marginella pallida, Linn		Gould	1
Marginella zonata, Kien	West Indies	Gould	21
Marginella zonata, Kien		Gould	21
Marginella puella, Gld		Gould	2
Marginella subtriplicate, d'Orb		Gould	4
Marginella avena, Val	West Indies		5
Marginella avena, Val	Bermuda	Gould	4
Marginella avena, Val		Gould	15
Marginella Philippinarum, Redf	Philippine Is	Gould	2
Marginella albolineata, d'Orb	California	Smithsonian	1

Family Olividæ.

NAME.	Locality.	Collection.	Specimens.
Subfamily Olivinæ.			
Genus Oliva, Swainson.			
Oliva porphyria, Linn	Panama		1
Oliva porphyria, Linn	La Paz, Lr. Cal	Gould	3
Oliva Peruviana, Lam		Gould	12
Oliva Peruviana, Lam	Peru		2
Oliva Peruviana, Lam			1
Oliva Peruviana, Lam	Peru, Chestnut p	Albany Inst	2
Oliva Peruviana, Lam	Is. of St. Mary's Pa. O.	Albany Inst	5
Oliva episcopalis, Lam		U. S. Ex. Exp	3
Oliva episcopalis, Lam		Gould	9
Oliva, guttata, Lam			3
Oliva, guttata, Lam		U. S. Ex. Exp	4
Oliva, guttata, Lam		Gould	4
Oliva inflata, Lam		Smithsonian	2
Oliva inflata, Lam	Pacific Ocean		4
Oliva inflata, Lam	Moluccas	Gould	19
Oliva inflata, Lam			10
Oliva elegans, Lam		Smithsonian	7
Oliva elegans, Lam	Fejee Is	Smithsonian	2
Oliva elegans, Lam		Gould	13
Oliva elegans, Lam. var. tricolor, Lam		Dr. Martin	2
Oliva elegans, Lam. var. tricolor, Lam			2
Oliva elegans, Lam. var. tricolor, Lam		Gould	15
Oliva elegans, Lam. var. tricolor, Lam		Smithsonian	3
Oliva bulbiformis, Ducl		Smithsonian	1

FAMILY OLIVIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Genus Oliva, Swainson — (*Concluded*).			
Oliva funebralis, Lam		Smithsonian	1
Oliva mustellina, Lam		Smithsonian	3
Oliva maura, Lam		Gould	8
Oliva maura, Lam		U. S. Ex. Exp	1
Oliva sanguinolenta, Lam		Gould	10
Oliva sanguinolenta, Lam		U. S. Ex. Exp	2
Oliva sanguinolenta, Lam			2
Oliva irisans, Lam.			1
Oliva irisans, Lam.	Calcutta	Gould	7
Oliva irisans, Lam., var. textilina, Lam			3
Oliva irisans, Lam., var. erythrostoma, Lam	E. Indies	Gould	2–9
Oliva irisans, Lam., var. erythrostoma, Lam			1
Oliva irisans, Lam., var. erythrostoma, Lam		Gould	4
Oliva irisans, Lam., var. erythrostoma, Lam		U. S. Ex. Ex	4
Oliva irisans, Lam., var. erythrostoma, Lam	Pacific Ocean		3
Oliva irisans, Lam., var. erythrostoma, Lam		Dr. Newcomb	1
Oliva irisans, Lam., var. erythrostoma, Lam		Albany Inst	1
Oliva irisans, Lam., var. tremulina, Lam		U. S. Ex. Ex	4
Oliva irisans, Lam., var. tremulina, Lam		Gould	1
Oliva araneosa, Lam	C. St. Lucas	Smithsonian	2
Oliva araneosa, Lam		Gould	5
Oliva araneosa, Lam	Gulf of California	Gould	2
Oliva araneosa, Lam			4
Oliva araneosa, Lam		Albany Inst	1

Oliva araneosa, Lam	Mazatlan	Gould	1
Oliva araneosa, Lam., var. Juliettæ, Ducl		Gould	4
Oliva araneosa, Lam., var. Juliettæ, Ducl	California	Gould	1
Oliva araneosa, Lam., var. Juliettæ, Ducl	Guacomayo	Smithsonian	1
Oliva angulata, Lam		Gould	4
Oliva angulata, Lam	Guaymas, G. of Cal	Gould	2
Oliva angulata, Lam	Panama		1
Oliva fusiformis, Lam		Gould	9
Oliva fusiformis, Lam			9
Oliva reticularis, Lam		Gould	17
Oliva litterata, Lam			16
Oliva litterata, Lam		Gould	6
Oliva litterata, Lam	North Carolina	Gould	9
Oliva litterata, Lam	Key West	Gould	8
Oliva litterata, Lam	W. coast Fla., S. of Tampa	F. J. H. Merrill	8
Oliva litterata, Lam	G. of Mexico		5
Oliva flammulata, Lam	W. Africa	Smithsonian	1
Oliva flammulata, Lam		Gould	1
Oliva Duclosi, Rve		Smithsonian	2
Oliva Duclosi, Rve		Gould	7
Oliva ispidula, Linn		Smithsonian	3
Oliva ispidula, Linn	Mergui, Burmah	Gould	2
Oliva ispidula, Linn		Gould	17
Oliva ispidula, Linn			2
Oliva tessellata, Lam		Gould	2
Oliva carneola, Gmel	Australia	Dr. Newcomb	1
Oliva carneola, Gmel		U. S. Ex. Ex.	9
Oliva carneola, Gmel		Gould	7
Oliva carneola, Gmel			2

Family Olividæ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Subgenus Callianax, H. & A. Adams.			
Oliva biplicata, Sowb		Smithsonian	3
Oliva biplicata, Sowb	Mazatlan	Gould	11
Oliva biplicata, Sowb		Gould	3
Subgenus Agaronia, Gray.			
Oliva hiatula, Gmel		Gould	2
Oliva hiatula, Gmel	W. Africa	Smithsonian	2
Oliva hiatula, Gmel	Panama	Gould	6
Oliva hiatula, Gmel	Liberia	Gould	6
Oliva acuminata, Lam			1
Oliva acuminata, Lam	W. Africa		1
Oliva acuminata, Lam		Gould	1
Oliva acuminata, Lam	W. Africa	Smithsonian	2
Oliva nebulosa, Lam			1
Oliva nebulosa, Lam	W. Africa	Smithsonian	1
Oliva nebulosa, Lam		Smithsonian	1
Oliva nebulosa, Lam		Gould	7
Oliva gibbosa, Born	Ceylon	Gould	4
Oliva gibbosa, Born		U. S. Ex. Exp	3
Oliva gibbosa, Born	Indian, O		2
Oliva gibbosa, Born			4
Oliva gibbosa, Born		Gould	3
Oliva gibbosa, Born		Smithsonian	1

Subgenus Olivancillaria, d'Orb.			
Oliva Brasiliana, Lam		Gould	2
Oliva auricularia, Lam	Rio Negro, S. A	U. S. Ex. Exp	2
Subgenus Lamprodoma, Swainson.			
Oliva volutella, Lam		Gould	18
Oliva volutella, Lam	Panama	Gould	9
Subfamily Olivinæ.			
Genus Olivella, Swainson.			
Olivella mutica, Say	North Carolina	Gould	70
Olivella petiolita, Ducl	Santa Barbara	Gould	35
Olivella petiolita, Ducl	San Juan, Lr. Cal	Gould	4
Olivella petiolita, Ducl		Gould	32
Olivella zonalis, Lam	Mazatlan	Gould	35
Olivella zonalis, Lam		Gould	7
Olivella columellaris, Sowb		Gould	4
Olivella nivea, Gmel		Gould	71
Olivella nivea, Gmel			9
Olivella lepta, Ducl		Gould	4
Olivella Fortunei, Adams		Gould	9
Olivella Anazora, Ducl	C. St. Lucas	Smithsonian	1
Olivella Anazora, Ducl		Gould	26
Olivella undatella, Lam		Gould	4
Olivella gracilis, Brod. & Sowb		Gould	4
Olivella gracilis, Brod. & Sowb	C. St. Lucas	Smithsonian	16
Olivella bætica, Carp		Smithsonian	5
Olivella dama, Mawe	Mazatlan	Gould	5
Olivella dama, Mawe		Gould	2

FAMILY OLIVIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Subfamily Ancillarinæ.			
Genus Ancillaria, Lam.			
Ancillaria cinnamomea, Lam		Gould	11
Ancillaria acuminata, Sowb		Gould	2
Ancillaria ampla, Gmel		Gould	10
Ancillaria cingulata, Sowb		Gould	1
Ancillaria cingulata, Sowb	From an island near New Holland	Gould	3
Ancillaria elongata, Gray		Gould	1
Subgenus Anolacia, Gray.			
Ancillaria Mauritiana, Sowb		Gould	9
Subgenus Dipsaccus, Klein.			
Ancillaria glabrata, Linn	West Indies		3
Ancillaria glabrata, Linn			1
Ancillaria glabrata, Linn		Gould	4
Ancillaria balteata, Swain		Gould	2
Subfamily Harpinæ.			
Genus Harpa, Lam.			
Harpa ventricosa, Lam	Indian O.		2
Harpa ventricosa, Lam		U. S. Ex. Ex	1
Harpa ventricosa, Lam		Gould	6
Harpa canoidalis, Lam		Gould	16
Harpa conoidalis, Lam	Indian O.		1

Harpa rosea, Lam		Gould	1
Harpa minor, Lam			2
Harpa minor, Lam		Gould	12
Harpa minor, Lam		Albany Inst	1
Harpa minor, Lam		U. S. Ex. Ex	4

FAMILY COLUMBELLIDÆ.

NAME.	Locality.	Collection.	Specimen.
Genus Columbella, Lam.			
Columbella strombiformis, Lam		Gould	3
Columbella strombiformis, Lam	Coast Peru	Albany Inst	9
Columbella Paytensis, Less		Gould	4
Columbella fuscata, Sowb		Gould	11
Columbella fuscata, Sowb	I. of Socos	Gould	7
Columbella fuscata, Sowb	Guayaquil	Gould	11
Columbella fuscata, Sowb	C. St. Lucas	Smithsonian	3
Columbella hæmastoma, Sowb	C. St. Lucas	Smithsonian	1
Columbella hæmastoma, Sowb		Gould	2
Columbella hæmastoma, Sowb	Gallapagos Island	Albany Inst	7
Columbella hæmastoma, Sowb	Panama	Gould	10
Columbella festiva, Kien	C. St. Lucas	Smithsonian	2
Columbella festiva, Kien		Gould	1
Columbella mercatoria, Linn	West Indies		2
Columbella mercatoria, Linn		Gould	29
Columbella mercatoria, Linn			32
Columbella mercatoria, Linn		Gould	33–28
Columbella mercatoria, Linn	Cumana, Venezuela	Gould	2
Columbella rustica, Linn	Brazil	Smithsonian	2
Columbella rustica, Linn		Gould	59
Columbella rustica, Linn	Mediterranean	Smithsonian	3
Columbella pardalina, Lam		Gould	8
Columbella pardalina, Lam	E. Indies	Gould	9
Columbella pardalina, Lam		Smithsonian	6
Columbella fulgurans, Lam		F. J. H. Merrill	18

Columbella fulgurans, Lam	E Indies	Gould	11
Columbella fulgurans, Lam		Smithsonian	6
Columbella fulgurans, Lam. var. punctata, Lam	E. Indies	Gould	6
Columbella fulgurans, Lam. var. punctata, Lam		Smithsonian	6
Columbella turturina, Lam	Pacific O	Gould	4
Columbella turturina, Lam		Smithsonian	2
Columbella palumbina, Gld. } Columbella turturina, Lam }		Gould	Types 35
Columbella versicolor, Sowb	E. Indies		3
Columbella versicolor, Sowb		Smithsonian	9
Columbella versicolor, Sowb		Gould	23–22
Columbella versicolor, Sowb	Sandwich Is		2
Columbella versicolor, Sowb		Gould	4
Columbella versicolor, Sowb	Philippine Is	Gould	2
Columbella varians, Sowb	Galapagos Is	Gould	48
Columbella varians, Sowb	Sandwich Is	Gould	17
Columbella varians, Sowb		Gould	55
Columbella Duclosiana, Sowb		Gould	8
Section Nitidella, Swains.			
Columbella lævigata, Linn		Gould	16
Columbella nitida, Lam	W. Indies		7
Celumbella nitida, Lam	Curacoa & Porto Rico	Gould	23
Columbella baccata, Gask	C. St. Lucas	Smithsonian	1
Columbella dichroa, Sowb		Gould	24
Columbella millepunctata, Carp	C. St. Lucas	Smithsonian	1
Section Alia, H. & A. Adams.			
Columbella carinata, Hinds	Santa Barbara	Gould	8
Columbella carinata, Hinds	Neeah Bay, W. T	Smithsonian	2
Columbella carinata, Hinds		Smithsonian	4

FAMILY COLUMBELLIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Alia, H. & A. Adams (*Continued*).			
Columbella Gouldii, Carp. / C. Carinata, Hinds	Santa Barbara	Gould	Types 1
Columbella gausapata, Gld.=C. carinata, Hinds	Puget Sound	Gould	Types 1
Columbella gausapata, Gld.=C. carinata, Hinds		Gould	Types 54
Columbella carinata, Hinds	California	Smithsonian	6
Columbella unifasciata, Sowb. / Columbella castanea, Gld.	Rio Janeiro	Smithsonian	3
Section Mitrella, Risso.			
Columbella Reevei, Carp.	C. St. Lucas	Smithsonian	1
Columbella Santa-Barbarensis, Carp. / Columbella Reevei, Carp.	Santa Barbara	Gould	1
Columbella ligula, Ducl.		Smithsonian	2
Columbella ligula, Ducl.		Gould	6
Columbella albina, Kien.		Smithsonian	1
Columbella cribraria, Lam.	Mazatlan	Gould	4
Columbella cribraria, Lam.	Cape St. Lucas	Smithsonian	2
Columbella cribraria, Lam.	Galapagos Is.	Gould	36
Columbella cribraria, Lam.		Gould	8
Columbella semiconvexa, Lam.		Gould	17
Columbella avena, Rve.		Gould	3
Columbella zebra, Gray		Smithsonian	2
Columbella zebra, Gray		Gould	7
Columbella scripta, Linn.	St. Thomas	Gould	2

Columbella scripta, Linn	Mediterranean Sea	Smithsonian	1–1
Columbella lunata, Say	Charleston Harbor, S. C.	Gould	3
Columbella dermestoides, Kien		Gould	9
Columbella chrysalloides, Carp	California	Smithsonian	1
Section Atilia, H. & A. Adams.			
Columbella minor, Scacc	Mediterranean Sea	Smithsonian	3
Columbella pungens, Gld	Port Lloyd, Bonin Is	Smithsonian	1
Columbella pungens, Gld	Port Lloyd, Bonin Is	Gould	Types 4
Columbella sagitta, Gask		Smithsonian	1
Columbella solidula, Rve	C. St. Lucas	Smithsonian	1
Section anachis, H. & A. Adams.			
Columbella rugosa, Sowb		Gould	17
Columbella rugosa, Sowb	Panama	Gould	4
Columbella costellata, Sowb		Gould	21
Columbella varia, Sowb	Mazatlan	Gould	1
Columbella varia, Sowb	Guayaquil	Gould	8
Columbella avara, Say		Gould	58
Columbella rosacea, Gld		Gould	12
Section Seminella, Pease.			
Columbella pygmæa, Sowb	Panama	Gould	3
Columbella nigricans, Sowb	Taboga	Gould	4
Columbella atrata, Gould	Hong Kong (Stimpson)	Smithsonian	1
Columbella atrata, Gould	Hong Kong	Gould	Types 2
Columbella fulminea, Gld	C. of Good Hope (Stimpson)	Smithsonian	1
Columbella minuscula, Gld	Ousima	Gould	Types 3
Columbella virginea, Gld	China Sea (Stimpson)	Gould	Types 2
Columbella zonata, Gld	Japan	Gould	Types 2

FAMILY COLUMBELLIDÆ—(*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Section Conidea, Swainson.			
Columbella ovulata, Lam		Gould	18
Columbella obtusa, Sowb		Gould	9
Columbella marmorata, Gray	Philippine Is	Smithsonian	1
Columbella dormitor, Sowb		Gould	5
Columbella flava, Brug		Gould	3
Columbella flava, Brug	Japan	Smithsonian	1
Columbella discors, Gmel	Manilla	Smithsonian	3
Section Meto, Reeve.			
Columbella Philippinarum, Rve		Gould	6
Columbella Philippinarum, Rve		Smithsonian	2
Columbella Philippinarum, Rve., var. coniformis, Sowb			1
Columbella Philippinarum, Rve., var. cedo-nulli, Rve.		Gould	1
Section Strombina, Morch.			
Columbella bicanalifera, Sowb	Panama	Gould	6
Columbella gibberula, Sowb	Taboga	Gould	4
Columbella maculosa, Sowb		Gould	1
Columbella recurva, Sowb	Panama	Gould	5
Genus Engina, Gray.			
Engina carbonaria, Rve	Galapagos Is	Gould	4
Engina carbonaria, Rve	Pacific Is	Smithsonian	1
Engina carbonaria, Rve		Smithsonian	1

Engina astricta, Rve		Smithsonian	1
Engina Reevei, Tryon		Gould	6
Engina Reevei, Tryon		Smithsonian	2
Engina farinosa, Gould	Sandwich Is	Gould	Types, 7
Engina albocincta, Pse		Gould	4
Engina funiculata, Rve	Pacific O	Smithsonian	2
Engina lineata, Rve		Smithsonian	1
Engina zonata, Rve		Smithsonian	1
Engina zonata, Rve		Smithsonian	2
Subgenus Pusiostoma, Swainson.			
Engina mendicaria, Linn		Gould	17
Engina mendicaria, Linn		Smithsonian	2
Genus Columbellina, d'Orb.			
Columbellina Harpiformis, Sowb	Taboga	Gould	1
Amphissa, H. & A. Adams.			
Amphissa corrugata, Rve	Neeah Bay or Vancouver	Smithsonian	14

Family Conidæ.

NAME.	Locality.	Collection.	Specimens.
Genus Conus, Linn.			
Conus marmoreus, Linn		U. S. Ex. Ex	4
Conus marmoreus, Linn		Gould	7
Conus nocturnus, Hwass		Gould	4
Conus araneosus, Hwass		Gould	2
Conus imperialis, Linn		U. S. Ex. Ex.	1
Conus imperialis, Linn		Gould	5
Section Literati.			
Conus literatus, Linn			2
Conus literatus, Linn		U. S. Ex. Ex.	1
Conus literatus, Linn	Zanzibar	Gould	4
Conus literatus, Linn., var. millepunctatus, Lam.		Gould	3
Conus musicus, Hwass		Gould	6
Conus musicus, Hwass		Smithsonian	2
Conus eburneus, Hwass		U. S. Ex. Ex.	5
Conus eburneus, Hwass		Gould	4
Conus tessellatus, Born		Gould	3–1
Conus tessellatus, Born		U. S. Ex. Ex.	2
Conus tessellatus, Born			2
Conus Proteus, Hwass	W. coast Florida	F. J. H. Merrill	2
Conus Proteus, Hwass		Gould	2–2
Conus Proteus, Hwass., var. papilionaceus, Hwass		Gould	1
Conus Proteus, Hwass., var. papilionaceus, Hwass	Cape Palmas	Smithsonian	2
Conus trochulus, Rve.		Gould	3
Conus venulatus, Hwass		Gould	4

Conus venulatus, Hwass., var. Crotchii, Rev		Gould		1
Conus genuanus, Hwass		Gould		2
Conus Prometheus, Hwass		Gould		1
Section Figulini.				
Conus betulinus, Linn		Martin		2
Conus betulinus, Linn				1
Conus betulinus, Linn		Gould		7
Conus glaucus, Hwass		Gould		1
Conus figulinus, Linn		U. S. Ex. Ex.		1
Conus figulinus, Linn				1
Conus figulinus, Linn		Gould		5
Conus figulinus, Linn., var. Loroisi, Kien				1
Conus quercinus, Hwass				2
Conus quercinus, Hwass		U S. Ex. Ex.		3
Conus quercinus, Hwass		Gould		9
Conus Californicus, Hinds	California	Smithsonian		1
Conus ravus, Gould.= C. Californicus, Hinds	California	Gould	Type	1
Conus ravus, Gould.= C. Californicus, Hinds.	Acapulco	Gould	Type	1
Section Arenati.				
Conus arenatus, Hwass		U. S. Ex. Ex.		5
Conus arenatus, Hwass		Gould		7
Conus obesus, Hwass		Gould		1
Conus pulicarius, Hwass		U. S. Ex. Ex.		3
Conus pulicarius, Hwass	Pacific O.	Gould		1
Conus pulicarius, Hwass		Gould		4
Conus Vautieri, Kien	Marquesas Is.	Gould		1
Conus stercus-muscarum, Linn		H. Cuming		1
Conus stercus-muscarum, Linn		Gould		2

FAMILY CONIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Mures.			
Conus mus, Hwass			3
Conus mus, Hwass		Gould	10
Conus punctatus, Chemn.		Gould	2
Conus Hebræus, Linn.			11
Conus Hebræus, Linn.		Gould	7–3
Conus Hebræus, Linn.		U. S. Ex. Ex.	3
Conus Hebræus, Linn.		Smithsonian	1
Conus Hebræus, Linn., var. vermiculatus, Hwass		Gould	8
Conus Hebræus, Linn., var. vermiculatus, Hwass		Smithsonian	1
Conus balteatus, Sowb.		Gould	1
Conus miliaris, Hwass.	Zanzibar.	Gould	12
Conus miliaris, Hwass.		Smithsonian	3
Conus miliaris, Hwass., var. abbreviatus, Nuttall.		Smithsonian	1
Conus miliaris, Hwass., var. abbreviatus, Nuttall.		Gould	10
Codus miliaris, Hwass., var. Aristophanes, Ducl.		Gould	1
Conus miliaris, Hwass., var. Aristophanes, Ducl.		Smithsonian	2
Conus taeniatus, Hwass.		Gould	4
Conus Ceylonensis, Hwass	Galapagos Is.		3
Conus Ceylonensis, Hwass	C. St. Lucas	Smithsonian	1
Conus Ceylonensis, Hwass	Zanzibar	Gould	4
Conus Ceylonensis, Hwass	Philippines	Gould	1
Conus Ceylonensis, Hwass., var. pusillus, Chemn.		Gould	
Conus Ceylonensis, Hwass., var. sponsalis, Chemn.		Smithsonian	3
Conus Ceylonensis, Hwass., var. sponsalis, Chemn.		Gould	2

Conus Ceylonensis, Hwass., var. nanus, Brod.	Loo Choo Is.	Gould	14
Conus pussillus, Gould.=C. Ceylonensis, Chemn.	Mazatlan	Gould	Type 1
Section Varii.			
Conus aurantius, Hwass		Gould	3
Conus varius, Linn.		Gould	2
Conus nebulosus, Sol.	West Indies		2
Conus nebulosus, Sol		Gould	4
Conus princeps, Linn	San Juan	Gould	2
Section Ammirales.			
Conus ammiralis, Linn		Gould	2
Conus castrensis, Gould		Gould	Type 1
Conus Amadis, Mart.		Gould	3
Conus acuminatus, Hwass		Gould	2–1
Conus Malaccanus, Hwass		Gould	3
Conus monile, Hwass	Ceylon		2
Conus monile, Hwass		Gould	1
Conus generalis, Linn		U. S. Ex. Ex	1
Conus generalis, Linn			1–1
Conus generalis, Linn		Gould	13
Conus generalis, Linn	Sandwich Islands	Gould	1
Conus Maldivus, Hwass		Gould	1
Conus Pealii, Green	W. coast Florida, s. of Tampa	F. J. H. Merrill	2
Conus regularis, Sowb.	Guaymas	Gould	2
Conus regularis, Sowb.	Mazatlan		1
Conus Floridanus, Gabb	Apalachicola	Gould	1
Section Capitanei.			
Conus Sumatrensis, Hwass.	Pacific Ocean		1
Conus Sumatrensis, Hwass.	Philippine Islands	H. Cuming	1

FAMILY CONIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Capitanei — (*Continued*).			
Conus vexillum, Gmel		Gould	4
Conus vexillum, Gmel		U. S. Ex. Ex	1
Conus miles, Linn		Gould	4
Conus miles, Linn		U. S. Ex. Ex	1
Conus miles, Linn	Philippines	H. Cuming	1
Conus miles, Linn	East Indies		1
Conus miles, Linn	Pacific Ocean		2
Conus capitaneus, Linn			1–2
Conus capitaneus, Linn		Gould	4
Conus capitaneus, Linn., var. mustelinus, Linn		U. S. Ex. Ex	2
Conus capitanens, Linn., var. mustelinus, Linn		Gould	2–2
Conus rattus, Hwass	Tahiti	Gould	2
Conus rattus, Hwass		Gould	1
Section Virgines.			
Conus Virgo, Linn		U. S. Ex. Ex	2
Conus Virgo, Linn		Gould	6
Conus pastinaca, Lam	Loo Choo Islands	Gould	1
Conus emaciatus, Rve		U. S. Ex. Ex	1
Conus flavidus, Lam		U. S. Ex. Ex	4
Conus flavidus, Lam	New Zealand	Gould	7
Conus lividus, Hwass	Sandwich Islands	Gould	3
Conus lividus, Hwass		Gould	1
Conus distans, Hwass	Sandwich Islands	Gould	1
Conus distans, Hwass		Gould	4

Section Dauci.			
Conus daucus, Hwass		U. S. Ex. Ex.	2
Conus daucus, Hwass		Gould	4
Conus daucus, Hwass			3
Conus daucus, Hwass	St. Croix, W. I.		1
Conus lithoglyphus, Meusch		Gould	3
Conus lithoglyphus, Meusch			1
Conus pulchellus, Swains	Zanzibar	Gould	2
Conus planorbis, Born		Gould	4
Conus planorbis, Born	Sandwich Is.	Gould	2
Conus planorbis, Born			1
Conus senator, Linn	Sandwich Is.	Gould	1
Conus lineatus, Chemn	Red Sea	Gould	3
Conus lignarius, Rve	Philippine Is.	H. Cuming	2
Section Magi.			
Conus consors, Sowb		Gould	2
Conus magus, Linn	Philippine Is.	H. Cuming	1
Conus magus, Linn		Gould	7
Conus magus, Linn			3
Conus pertusus, Hwass		Gould	2
Conus mercator, Linn	Senegal	Gould	4
Conus spectrum, Linn		Gould	3–1
Conus spectrum, Linn., var. lacteus Lam		Gould	1
Conus spectrum, Linn., var. dolium, Boivin		Gould	2
Conus lignarius, Rve	Philippine Is.	Gould	1
Conus cinereus, Hwass		Gould	6
Conus cinereus, Hwass			1
Conus cinereus, Hwass	Africa	Gould	2
Conus nisus, Chemn			2
Conus radiatus, Gmel		Gould	2

Family Conidæ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Magi — (*Continued*).			
Conus ochroleucus, Gmel		U. S. Ex. Ex.	1
Conus puncticulatus, Hwass	Mazatlan	Gould	1
Conus puncticulatus, Hwass	Acapulco	Gould	3
Conus puncticulatus, Hwass		Gould	5
Conus puncticulatus, Hwass	Camana, Venezuela	Gould	7
Conus interruptus, Brod	C. St. Lucas	Smithsonian	1
Conus intertuptus, Brod		Gould	5
Section Achatini.			
Conus catus, Hwass		Gould	7
Conus catus, Hwass	Sandwich Is	Gould	1
Conus achatinus, Chemn		Gould	3
Conus achatinus, Chemn	Mergui	Gould	2
Conus monachus, Linn		Gould	3
Conus purpurascens, Brod		Gould	1
Conus purpurascens, Brod., var. regalitatus, Sowb	Panama		1
Conus testudinarius, Mart		Gould	5
Conus fulmen, Rve		Gould	1
Conus Mediterraneus, Hwass	Mediterranean Sea	Smithsonian	1
Conus Mediterraneus, Hwass	Mediterranean Sea	Gould	7
Conus aplustre, Rve	Cape of Good Hope	Gould	1
Conus anemone, Lam	Australia	Gould	2
Conus anemone, Lam		Gould	2

Section Asperi.			
Conus australis, Chemn	China		1
Conus australis, Chemn		Gould	1
Conus sulcatus, Hwass	Batavia	Gould	2
Conus acutangulus, Hwass		Gould	2
Conus verrucosus, Hwass		Gould	8
Section Terebri.			
Conus glans, Hwass		Gould	3
Conus scabriusculus, Chemn		Gould	1
Conus terebra, Born			1
Conus terebra, Born		U. S. Ex. Exp	1
Conus terebra, Born		Gould	2
Conus nussatella, Linn		Gould	4
Conus nussatella, Linn		U. S. Ex. Exp	1
Conus clavus, Linn		Gould	1
Conus granulatus, Linn		Gould	1
Conus aurisiacus, Linn		Gould	1
Conus cylindraceus, Brod. and Sowb		Gould	1
Conus puncturatus, Hwass		Gould	1
Section Bulbi.			
Conus hieroglyphicus, Ducl		Gould	2
Section Tulipæ.			
Conus striatus, Linn		U. S. Ex. Exp	2
Conus striatus, Linn			1
Conus striatus, Linn	Philippine Is	H. Cuming	2
Conus striatus, Linn		Gould	4–1
Conus gubernator, Hwass	Seychelles	H. Cuming	1
Conus gubernator, Hwass		Gould	2

FAMILY CONIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Section Tulipæ — (*Continued*).			
Conus gubernator, Hwass			1
Conus geographus, Linn		Gould	4
Conus tulipa, Linn		U. S. Ex. Exp	1
Conus tulipa, Linn		Gould	2
Conus violaceus, Rve		Gould	2
Conus bullatus, Linn		Gould	1
Section Texti.			
Conus aureus, Hwass		Gould	1
Conus pyramidalis, Lam			2
Conus textile, Linn		Gould	11
Conus textile, Linn		H. Cuming	1
Conus textile, Linn., var. verriculum, Linn			4
Conus textile, Linn., var. verriculum, Linn		U. S. Expl. Exped	1
Conus textile, Linn., var. verriculum, Linn		H Cuming	1
Conus textile, Linn , var. verriculum, Linn		Gould	3–1
Conus textile, Linn., var. achiepiscopus, Hwass	Philippine Islands	H. Cuming	1
Conus textile, Linn., var. Victoriæ, Rve	Australia	Gould	1
Conus abbas, Hwass		Gould	2
Conus omaria, Hwass		Gould	6
Conus omaria, Hwass	Philippine Islands	H. Cuming	1
Conus omaria, Hwass., var. colubrinus, Lam			1
Conus aulicus, Linn		U. S. Expl. Exped	1
Conus aulicus, Linn		Gould	5

Family Terebridæ.

NAME.	Locality.	Collection.	Specimens.
Genus Terebra, Adanson.			
Terebra crenulata, Linn		U. S. Expl. Exped	2
Terebra crenulata, Linn		Gould	2
Terebra dimidiata, Linn			1
Terebra dimidiata, Linn		U. S. Expl. Exped	2
Terebra dimidiata, Linn		Gould	5
Terebra maculata, Linn		U. S. Expl. Exped	3
Terebra maculata, Linn	Indian Ocean	Gould	5
Terebra maculata, Linn	Pacific Ocean		4
Terebra muscaria, Lam		U. S. Expl. Exped	2
Terebra muscaria, Lam	Madagascar	Gould	5
Terebra subulata, Linn	Pacific Ocean	U. S. Expl. Exped	1
Terebra subulata, Linn		W. Newcomb	2
Terebra subulata, Linn		Gould	4
Terebra tigrina, Gmel		Gould	3
Terebra tigrina, Gmel		U. S. Expl. Exped	1
Terebra oculata, Lam		U. S. Expl. Exped	2
Terebra oculata, Lam		Gould	3
Terebra robusta, Hinds	Panama	Gould	1
Terebra chlorata, Lam		Smithsonian	1
Terebra chlorata, Lam		Gould	2
Terebra flammea, Lam	Truxillo, S. A.	Gould	2
Terebra strigata, Sowb		Gould	2
Terebra cerithina, Lam		Gould	4
Terebra lanceata, Linn		Gould	2
Terebra affinis, Gray		Gould	7

FAMILY TEREBRIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Genus Terebra — (*Continued*).			
Terebra variegata, Gray	Lower Cal	Gould	4
Terebra variegata, Gray	C. St. Lucas	Smithsonian	1
Terebra Senegalensis, Lam	Senegal	Gould	1
Terebra Senegalensis, Lam	Gambia	Smithsonian	1
Terebra Dussumieri, Kien		Gould	1
Terebra duplicata, Linn	Pacific O	Gould	8
Terebra duplicata, Linn		Smithsonian	2
Terebra dislocata, Say		Gould	41
Terebra dislocata, Say	South America	Gould	9
Terebra cancellata, Quoy		Smithsonian	1
Terebra cancellata, Quoy	Sandwich Is	Smithsonian	2
Terebra undulata, Gray		Smithsonian	1
Terebra pertusa, Born		Gould	3
Terebra nebulosa, Sowb	Madagascar	Gould	3
Terebra myuros, Lam		Gould	1
Terebra myuros, Lam		Gould	1
Terebra cingulifera, Lam		Gould	3
Terebra cingulifera, Lam		Smithsonian	1
Terebra Babylonia, Lam		Gould	2
Terebra Babylonia, Lam		Smithsonian	2
Terebra staminea, Gray	Madagascar	Gould	2
Terebra cærulescens, Lam			3
Terebra cærulescens, Lam		Smithsonian	2
Terebra cærulescens, Lam	Indian O	Gould	6
Terebra cinerea, Born	St. Thomas, W. I	Gould	2

Terebra aciculina, Rve	Pacific O	Gould	11
Terebra strigilata, Linn		Gould	3
Terebra strigilata, Linn	Chinese seas	Gould	2
Terebra hastata, Gmel	St. Thomas, W. I	Gould	2
Terebra nitita, Hinds		Smithsonian	1
Terebra plumbea, Quoy	Australia	Smithsonian	2
Subgenus Euryta, H. & A. Adams.			
Terebra aciculata, Lam		Gould	148
Terebra arguta, Gould	Mazatlan	Gould	Types 8

FAMILY CANCELLARIIDÆ.

NAME.	Location.	Collection.	Specimens.
Subgenus Cancellaria, Lam.			
Cancellaria Spengleriana, Desh	....	Gould	2
Cancellaria Buccinoides, Sowb	Callao, Peru	Gould	3
Cancellaria urceolata, Hinds	Mazatlan	Gould	....
Cancellaria reticulata, Linn	....	Gould	4
Cancellaria reticulata, Lam	....	....	2
Cancellaria decusata, Sowb	....	Gould	1
Cancellaria cancellata, Linn	....	Gould	4
Cancellaria chrysostoma, Sowb	....	Gould	5
Cancellaria hæmastoma	....	Gould	1
Cancellaria tessellata, Sowb.	....	Gould	1
Cancellaria clavatula, Sowb	Taboga	Gould	2
Section Trigonostoma, Blainv.			
Cancellaria piscatoria, Gmel	Gambia, W. Africa	Gould	2
Cancellaria goniostoma, Sowb	Acapulco	Gould	1
Cancellaria goniostoma, Sowb	Central America	Gould	2
Cancellaria goniostoma, Sowb	....	Gould	1
Cancellaria scalarina, Lam	....	Gould	1
Cancellaria crenifera, Sowb	Mergui	Gould	1
Cancellaria obliquata, Lam	....	Gould	1
Cancellaria scalata, Sowb	Australia	Gould	1

FAMILY STROMBIDÆ.

NAME.	Locality.	Collection.	Specimens.
Subfamily Strombinæ.			
Genus Strombus, Linn., 1758.			
Strombus gigas, Linn		Gould	1
Strombus gigas, Linn. (immature)			3
Strombus galeatus, Swains		Gould	1
Strombus bubonius, Lam		Smithsonian	1
Strombns bubonius, Lam	Corisco, W. A	Gould	1
Strombus pugilis, Linn	West Indies		2
Strombus pugilis, Linn			3
Strombus pugilis, Linn	Aspinwall		2
Strombus pugilis, Linn		Gould	12
Strombus pugilis, Linn	West Indies (Immature)	Gould	2
Strombus pugilis, Linn., var. alatus, Linn		Gould	1
Strombus pugilis, Linn., var. alatus, Gmel	W. coast Florida	F. J. H. Merrill	1
Strombus gracilior, Sowb		Gould	3
Strombus gracilior, Sowb.	Mazatlan	Gould	1
Strombus canarium, Linn		Gould	3
Strombus canarium, Linn		U. S. Ex	1
Strombus canarium, Linn		W. Newcomb	1
Strombus canarium, Linn	Ceylon	Gould	1
Strombus canarium, Linn., var. Isabella, Lam		Gould	5
Strombus granulatus, Gray			1
Strombus granulatus, Gray		Gould	1
Strombus granulatus, Gray		Gould	3

FAMILY STROMBIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Euprotomus, Gill.			
Strombus lentiginosus, Linn			4
Strombus lentiginosus, Linn		U. S. Ex. Ex	2
Strombus lentiginosus, Linn	E. Indies		3
Strombus lentiginosus, Linn		Gould	3
Strombus papilio, Chemn		Gould	1
Strombus latissimus, Linn		Gould	1
Section Monodactylus, Klein.			
Strombus Peruvianus, Swains		Gould	1
Strombus tricornis, Lam		Gould	5
Strombus bituberculatus, Lam	West Indies	F. J. H. Merrill	2
Strombus bituberculatus, Lam	Carthagena, S. A		
Strombus bituberculatus, Lam		Gould	3–1
Strombus gallus, Linn	West Indies		2
Strombus gallus, Linn	Bahama Is	Gould	1
Strombus gallus, Linn			2
Strombus auris-Dianæ, Linn		W. Newcomb	1
Strombus auris-Dianæ, Linn		U. S. Ex. Ex	1
Strombus auris-Dianæ, Linn		Gould	4
Strombus auris-Dianæ, Linn., var. melanostomus, Swains		Gould	2
Strombus Pacificus, Swains	Australia	Gould	1
Strombus Pacificus, Swains		Gould	1

Section Gallinula, Klein.			
Strombus vittatus, Linn		U. S. Ex. Ex.	1
Strombus vittatus, Linn			1–3
Strombus vittatus, Linn		Gould	10
Strombus Campbelli, Gray			8
Strombus Campbelli, Gray		Gould	2
Strombus dilatatus, Swains	Madagascar	Gould	3
Strombus Japonicus, Rve		Gould	2
Strombus columba, Lam	Zanzibar and Phil. Is.	Gould	2
Strombus marginatus, Linn		Gould	2
Strombus epidromus, Linn		U. S. Ex. Ex.	2
Strombus epidromus, Linn		Gould	4
Strombus succinctus, Linn		Gould	3
Strombus succinctus, Linn., var. septimus, Ducl		U. S. Ex. Ex.	2
Strombus fusiformis, Sowb		Gould	1
Strombus variabilis, Swains		Gould	3
Strombus minimus, Linn		Gould	5
Strombus minimus, Linn	E. Indies	Gould	3
Section Canarium, Schum. 1817.			
Strombus urceus, Linn		U. S. Ex. Ex.	3
Strombus urceus, Linn		Smithsonian	2
Strombus urceus, Linn		Gould	6
Strombus dentatus, Linn	Fejee Is	U. S. Ex. Ex.	9
Strombus dentatus, Linn	Akaba	Gould	2
Strombus dentatus, Linn		Gould	16
Strombus dentatus, Linn			2
Strombus dentatus, Linn	Red sea	Smithsonian	1
Strombus dentatus, Linn		Smithsonian	1
Strombus dentatus, Linn., var. rugosus, Sowb	Phillippine Is	Gould	1
Strombus dentatus, Linn., var. pulchellus, Rve			

Family Strombidæ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Section Canarium, Schum. 1817 — (*Concluded*).			
Strombus floridus, Lam		U. S. Ex. Ex.	14
Strombus floridus, Lam		Gould	17
Strombus, fasciatus, Born		Gould	2
Strombus maculatus, Nutt		Gould	8
Strombus gibberulus, Linn		U. S. Ex. Ex.	5
Strombus gibberulus, Linn			3
Strombus gibberulus, Linn		W. Newcomb	6
Strombus gibberulus, Linn		Gould	3
Strombus gibberulus, Linn	Indian Ocean	Gould	8
Strombus gibberulus, Linn		Albany Inst	1
Strombus terebellatus, Sowb		Gould	4
Strombus Samar, Chemn		Gould	3
Section Conomurex, Bayle, 1884.			
Strombus Mauritianus, Lam		Gould	3
Strombus Luhuanus, Linn			7
Strombus Luhuanus, Linn		U. S. Ex. Ex	7
Strombus Luhuanus, Linn		Gould	6
Genus Pterocera, Lam., 1799.			
Section Pterocera.			
Subsection Heptadactylus, Klein.			
Pterocera lambis, Linn			1
Pterocera lambis, Linn		Gould	39
Pterocera lambis, Linn	India		4

Pterocera lambis, Linn		U. S. Ex. Ex	3
Pterocera aurantia, Lam		Gould	2
Pterocera bryonia, Gmel		Gould	3
Pterocera bryonia, Gmel		U. S. Ex. Ex	2
Pterocera bryonia, Gmel	Indian Ocean	John C. Smock	2
Subsection Millipes, Klein.			
Pterocera scorpio, Linn		Gould	3
Pterocera pseudo-scorpio, Lam		Gould	2
Pterocera millepeda, Linn		Gould	2
Pterocera elongata, Swains		Gould	1
Section Harpago, Klein, 1753.			
Pterocera chiragra, Linn		Gould	2
Pterocera chiragra, Linn		U. S. Ex. Ex	1
Pterocera chiragra, Linn		Gould	1–1
Pterocera rugosa, Sowb		Gould	2
Pterocera rugosa, Sowb			3
Pterocera rugosa, Sowb	Fejee Is	U. S. Ex. Ex	1
Genus Rostellaria, Lam., 1799.			
Rostellaria curvirostris, Lam		Gould	3
Genus Terebellum, Klein, 1853.			
Terebellum subulatum, Lam		Gould	10
Terebellum subulatum, Lam		Smithsonian	1
Subfamily Aporrhainæ.			
Genus Aporrhais, Dillwyn, 1823.			
Aporrhais pes-pelecani, Linn	Great Britain		1
Aporrhais pes-pelecani, Linn			2
Aporrhais pes-pelecani, Linn	Mediterranean Sea	Gould	1

FAMILY STROMBIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Subfamily Struthiolariinæ.			
Genus Struthiolaria, Lam., 1812.			
Struthiolaria papulosa, Mart		U. S. Ex. Ex	2
Struthiolaria vermis, Mart	N. Zealand	Smithsonian	2

Family Cypræidæ.

NAME.	Locality.	Collection.	Specimens.
Genus Cypræa, Linn.			
Cypræa argus, Linn	Canton, China		1
Cypræa argus, Linn	Mauritius	W. Newcomb	1
Cypræa argus, Linn		U. S. Ex. Ex.	2
Cypræa argus, Linn		Gould	5
Cypræa cervus, Linn		Gould	1
Cypræa exanthema, Linn		Gould	8
Cypræa exanthema, Linn	S. America and West Indies		5
Cypræa exanthema, Linn		U. S. Ex. Ex.?	4
Cypræa exanthema, Linn	West Indies		2
Cypræa exanthema, Linn., var. cervinetta, Kien		Gould	3
Cypræa scurra, Chemn		U. S. Ex. Ex.	2
Cypræa scurra, Chemn		Gould	6
Cypræa testudinaria, Linn		U. S. Ex. Ex.	1
Cypræa testudinaria, Linn			2
Cypræa testudinaria, Linn		Gould	2
Cypræa Isabella, Linn		U. S. Ex. Ex.	1
Cypræa Isabella, Linn	Sandwich Is		5
Cypræa Isabella, Linn		Gould	7
Cypræa lurida, Linn	West Indies		2
Cypræa lurida, Linn	Mediterranean sea	Smithsonian	1
Cypræa lurida, Linn		Gould	7
Cypræa cinera, Gmel		Gould	6
Cypræa carneola, Linn		U. S. Ex. Ex.	7
Cypræa carneola, Linn	Sandwich Is		2
Cypræa carneola, Linn	East Indies		6

FAMILY CYPRÆIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Genus Cypræa, Linn.—(*Continued*).			
Cypræa carneola, Linn		Gould	7
Cypræa talpa, Linn		Gould	5
Cypræa talpa, Linn		U. S. Ex. Ex.	4
Cypræa talpa, Linn	Sandwich Is.	W. Newcomb	2
Cypræa interrupta, Gray		Smithsonian	1
Cypræa quadrimaculata, Gray		Gould	....
Cypræa irrorata, Sol		Gould	2
Cypræa irrorata, Sol		Smithsonian	1
Cypræa fimbriata, Gmel		Gould	30
Cypræa macula, Adams		Gould	2
Cypræa irescens, Adams		Smithsonian	1
Cypræa felina, Gmel		Gould	3
Cypræa felina, Gmel., var. fabula, Kien		Gould	4
Cypræa felina, Gmel., var. ursellus, Gmel		Gould	5
Cypræa hirundo, Linn		Gould	5
Cypræa hirundo, Linn		Gould	4
Cypræa neglecta, Sowb		Gould	2
Cypræa neglecta, Sowb		Smithsonian	3
Cypræa cylindrica, Born		Gould	3
Cypræa cylindrica, Born		Smithsonian	1
Cypræa tabescens, Sol		Gould	3
Cypræa tabexcens, Sol		Smithsonian	2
Cypræa caurica, Linn		Gould	1–2
Cypræa caurica, Linn		U. S. Ex. Ex.	5

Cypræa caurica, Linn		Gould	19
Cypræa caurica, Linn	South seas		4
Cypræa caurica, Linn		Smithsonian	2
Cypræa cruenta, Gmel		Gould	9
Cypræa stolida, Linn		Gould	1
Cypræa ventriculus, Lam		Gould	3
Cypræa ventriculus, Lam			2
Cypræa arenosa, Gray		Gould	5
Cypræa sulcidentata, Gray		Gould	3
Cypræa tessellata, Swains		U. S. Ex. Ex.	1
Cypræa tessellata, Swains		Gould	2
Cypræa Mauritiana, Linn	Sandwich Is		2
Cypræa Mauritiana, Linn	Canton	Gould	3
Cypræa Mauritiana, Linn		U. S. Ex. Ex.	3
Cypræa Mauritiana, Linn		Gould	8
Cypræa caput-serpentis, Linn	West Coast Africa		1
Cypræa caput-serpentis, Linn		U. S. Ex. Ex.	7
Cypræa caput-serpentis, Linn	Sandwich Is		6
Cypræa caput-serpentis, Linn		Gould	11
Cypræa mappa, Linn		Gould	7
Cypræa mappa, Linn			1
Cypræa mappa, Linn		U. S. Ex. Ex.	1
Cypræa mappa, Linn	Madagascar	W. Newcomb	1
Cypræa Arabica, Linn	Indian O	W. Newcomb	1
Cypræa Arabica, Linn		U. S. Ex. Ex.	4
Cypræa Arabica, Linn	China		4
Cypræa Arabica, Linn		Gould	11
Cypræa reticulata, Martyn		Gould	5
Cypræa reticulata, Martyn		U. S. Ex. Ex.	2
Cypræa reticulata, Martyn	Pacific O		4
Cypræa histrio, Meusch		Gould	7

FAMILY CYPRÆIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Genus Cypræa, Linn.— (*Continued*).			
Cypræa histrio, Meusch			1
Cypræa arabicula, Lam.		Gould	4
Cypræa arabicula, Lam.		Gould	7
Cypræa stercoraria, Linn		Gould	6
Cypræa Thersites, Gask		Gould	1
Cypræa mus, Linn	West Indies		4
Cypræa mus, Linn		Smithsonian	5
Cypræa mus, Linn		Gould	6
Cypræa leucostoma, Gask		Gould	1
Cypræa moneta, Linn		U. S. Ex. Ex.	4
Cypræa moneta, Linn			2
Cypræa aurantia, Martyn		U. S. Ex. Ex.	1
Cypræa aurantia, Martyn.		Gould	1
Cypræa tigris, Linn		Gould	7
Cypræa tigris, Linn	Canton	Gould	2
Cypræa tigris, Linn	Pacific O.		3
Cypræa tigris, Linn		U. S. Ex. Ex.	4
Cypræa tigris, Linn			1
Cypræa pantherina, Sol			1
Cypræa pantherina, Sol		Smithsonian	1
Cypræa pantherina, Sol		Gould	4
Cypræa vitellus, Linn			1
Cypræa vitellus, Linn	Sandwich Is.	Wesley Newcomb	1
Cypræa vitellus, Linn		U. S. Ex. Ex.	4
Cypræa vitellus, Linn		Gould	2–6

Cypræa vitellus, Linn	China		3
Cypræa camelopardalis, Perry		Gould	2
Cypræa onyx, Linn		U. S. Ex. Ex.	1
Cypræa onyx, Linn	Australia		2
Cypræa onyx, Linn		Gould	5
Cypræa onyx var. nymphæa, Ducl		Gould	1
Cypræa lynx, Linn		Gould	24
Cypræa lynx, Linn	Sandwich Is.		6
Cypræa lynx, Linn		U. S. Ex. Ex	8
Cypræa errones, Linn		Smithsonian	2
Cypræa errones, Linn		Gould	9
Cypræa pulchella, Swains		Gould	1
Cypræa nigropunctata, Gray		Gould	2
Cypræa Sowerbyi, Kien	C. St. Lucas, L. Cal	Smithsonian	1
Cypræa lentiginosa, Gray		Gould	1
Cypræa zonata, Chemn	Senegal	Gould	1
Cypræa zonata, Chemn		Gould	4
Cypræa picta, Gray		Gould	2
Cypræa punctulata, Gray		Gould	9
Cypræa undata, Lam		Smithsonian	1
Cypræa undata, Lam	Pacific O.		1
Cypræa undata, Lam	Philippine Is	Gould	1
Cypræa ziczac, Linn	Ceylon and Honolulu	Gould	12
Cypræa lutea, Gronov	Philippines	Gould	2
Cypræa asellus, Linn	Indian O.		2
Cypræa asellus, Linn	China Sea		3
Cypræa asellus, Linn		Smithsonian	3
Cypræa clandestina, Linn	Ceylon	Gould	14
Cypræa clandestina, Linn		Smithsonian	1
Cypræa punctata, Linn		Smithsonian	1
Cypræa punctata, Linn		Gould	1

FAMILY CYPRÆIDIDÆ — (*Continued*).

NAME.	Locality.	Collection.	Specimens.
Genus Cypræa, Linn.— (*Continued*).			
Cypræa piperita, Sol	Australia	Gould	2
Cypræa cribraria, Linn		Smithsonian	1
Cypræa esontropia, Ducl		Gould	2
Cypræa Cumingii, Gray		Smithsonian	1
Cypræa miliaris, Gmel		Gould	1
Cypræa miliaris, Gmel			1
Cypræa eburnea, Barnes		U. S. Ex. Ex	2
Cypræa eburnea, Barnes		Gould	1
Cypræa turdus, Lam		Gould	2
Cypræa turdus, Lam	Red sea	Gould	6
Cypræa erosa, Linn		Gould	5–1
Cypræa erosa, Linn		Gould	9
Cypræa erosa, Linn		W. Newcomb	3
Cypræa erosa, Linn		U. S. Ex. Ex	4
Cypræa erosa, Linn			4
Cypræa ocellata, Linn	Ceylon		2
Cypræa poraria, Linn		Smithsonian	1
Cypræa poraria, Linn		Gould	2
Cypræa albuginosa, Mawe	C. St. Lucas, L. Cal	Smithsonian	1
Cypræa albuginosa, Mawe		Gould	3
Cypræa helvola, Linn		Gould	2
Cypræa helvola, Linn		Smithsonian	3
Cypræa helvola, Linn	Sandwich Is		5
Cypræa helvola, Linn	Sandwich Is	Smithsonian	1
Cypræa semiplota, Migh		Gould	39
Cypræe semiplota, Migh	Sandwich Is	Smithsonian	1

Cypræa spurca, Linn		Gould	9
Cypræa flaveola, Linn		Gould	3
Cypræa flaveola, Linn		Smithsonian	2
Cypræa Cernica, Sowb	Pacific Ocean		2
Cypræa Cernica, Sowb	E. Indies		1
Cypræa gangrænosa, Sol		Gould	5
Cypræa edentula, Sowb	C. of Good Hope	Gould	1
Cypræa staphylæa, Linn	Ceylon	Smithsonian	2
Cypræa staphylæa, Linn			4
Cypræa staphylæa, Linn		Gould	5
Cypræa nucleus, Linn			1
Cypræa nucleus, Linn		Smithsonian	2
Cypræa Madagascariensis, Gmel		U. S. Ex. Ex	1
Cypræa Madagascariensis, Gmel		Smithsonian	1
Cypræa annulata, Gray		Gould	3
Cypræa cicercula, Linn		Smithsonian	2
Cypræa globulus, Linn		Gould	2
Subgenus Trivia, Gray.			
Cypræa oryza, Lam		Smithsonian	3
Cypræa insecta, Migh		Smithsonian	2
Cypræa insecta, Migh	Sandwich Is		4
Cypræa insecta, Migh		Gould	84
Cypræa vitrea, Gask		Gould	4
Cypræa globosa, Gray		Gould	3
Cypræa pediculus, Linn	West Indies		10
Cypræa pediculus, Linn		Gould	2
Cypræa suffusa, Gray		Gould	10
Cypræa Pacifica, Gray	West Indies	Gould	5
Cypræa Pacifica, Gray	Acapulco	Gould	4
Cypræa quadripunctata, Gray	West Indies		5

FAMILY CYPRÆIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Subgenus Trivia, Gray — (*Concluded*).			
Cypræa exigua, Gray			9
Cypræa exigua, Gray	Sandwich Is	W. Newcomb	3
Cypræa exigua, Gray		Smithsonian	1
Cypræa gemmula, Gould = C. exigua, Gray		Gould	T'pes 105
Cypræa Californica, Gray		Smithsonian	1
Cypræa Californica, Gray		Gould	3
Cypræa sanguinea, Gray		Gould	1
Cypræa sanguinea, Gray	Mazatlan	Gould	3
Cypræa subrostrata, Gray	West Indies		1
Cypræa subrostrata, Gray		Gould	9
Cypræa candidula, Gask		Smithsonian	1
Cypræa Europæa, Mont	Great Britain		9
Cypræa Europæa, Mont	Gibraltar		2
Cypræa Europæa, Mont		Gould	5
Cypræa Napolina, Ducl	Senegal	Gould	1
Cypræa Australis, Lam		Gould	2
Cypræa pulex, Sol	Mediterranean Sea	Smithsonian	1

FAMILY OVULIDÆ.

NAME.	Locality.	Collection.	Specimens.
Genus Ovula, Brugiere, 1789.			
Ovula ovum, Linn	S. Pacific		1
Ovula ovum, Linn	China Sea		1
Ovula ovum, Linn			1
Ovula ovum, Linn	Singapore	U. S. Ex. Ex	2
Ovula bullata, Adams & Rve		Gould	3
Subgenus Cyphoma, Bolton.			
Ovula gibbosa, Linn	West Indies		7
Ovula intermedia, Sowb	Cumana and Brazil	Gould	5
Subgenus Vola, Bolton, 1798.			
Ovula volva	China		1
Subgenus Neosimnia, Fisher, 1884.			
Ovula uniplicata, Sowb	Santa Barbara, Cal	Gould	1
Subgenus Calpurnus, Montfort, 1810.			
Ovula verrucosa, Linn		U. S. Ex. Ex	2

FAMILY CASSIDIDÆ.

NAME.	Locality.	Collection.	Specimens.
Genus Cassis, Klein, 1753.			
Cassis cornuta, Linn		Gould	1
Cassis cameo, Stimp		Gould	1–1
Cassis cameo, Stimp		Gould	1–1
Cassis tuberosa, Linn		Jno. C. Smock	1
Cassis fimbriata, Quoy		Gould	4
Section Levenia, Gray, 1847.			
Cassis coarctata, Gray	San Juan, L. Cal	Gould	3
Cassis coarctata, Gray	C. St. Lucas	Smithsonian	1
Section Cypræcassis, Stutch, 1837.			
Cassis tenuis, Gray		Gould	1
Cassis testiculus, Linn	St. Croix, W. I.		2
Cassis testiculus, Linn		Gould	6
Cassis testiculus, Linn	West Indies		6
Cassis rufa, Linn		Gould	1
Cassis rufa, Linn			1
Subgenus Semicassis, Klein, 1753.			
Cassis sulcosa, Brug		Gould	6
Cassis sulcosa, Brug	G. of Mexico, near Mobile	Gould	1
Cassis sulcosa, Brug	Portsmouth, N. C	Gould	2
Cassis sulcosa, Brug	Florida		1
Cassis sulcosa, Brug			1–1
Cassis sulcosa, Brug		Gould	7

Cassis sulcosa, Brug	Texas		3
Cassis sulcosa, Brug			2
Cassis sulcosa, Brug	W. coast Fla., S. of Tampa	F. J. H. Merrill	2
Cassis sulcosa, Brug., var abbreviata, Lam	C. St. Lucas	Smithsonian	1
Cassis canaliculata, Brug	Philippine Is	Gould	3
Cassis saburon, Adan		Gould	3
Cassis saburon, Adan	Maderia		1
Cassis suburon, Adan., var. pila, Rve		Smithsonian	2
Cassis saburon, Adan., var. Japonica, Rve		Gould	1
Section Bezoardica, Schum., 1817.			
Cassis glauca, Linn		Gould	3
Cassis cornulata, Sowb		Gould	1
Cassis areola, Linn		Gould	5
Cassis areola, Linn			1
Cassis areola, Linn		U. S. Ex. Ex	1
Cassis strigata, Gmel		Gould	3
Cassis strigata, Gmel			1
Cassis plicata, Linn		Gould	1
Section Casmaria, H. & A. Adams, 1853.			
Cassis vibex, Linn		Gould	9
Cassis vibex, Linn	Pacific Ocean		1
Cassis vibex, Linn		U. S. Ex. Ex	3
Cassis vibex, Linn., var. erinacea, Linn	Tahati	U. S. Ex Ex	1
Cassis vibex, Linn., var. erinacea, Linn		Gould	7
Cassis achatina, Lam		Gould	1
Cassis achatina, Lam., var. pyrum, Lam		Gould	2
Genus Cassidaria, Lam., 1812.			
Cassidaria echinaphora, Linn		Gould	4
Cassidaria Tyrrhena, Lam		Gould	4

FAMILY CASSIDIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Genus Oniscia, Sowb., 1824.			
Oniscia oniscus, Linn		Gould	9
Oniscia oniscus, Linn	St. Croix, W. I.		2
Oniscia oniscus, Linn	West Indies		1
Oniscia cancellata, Sowb		Gould	4

FAMILY DOLIIDÆ.

NAME.	Locality.	Collection.	Specimens.
Genus Dolium, Lam., 1801.			
Dolium galea, Linn		Gould	5
Dolium olearium, Brug		Gould	6
Dolium olearium, Brug			1–2
Dolium fasciatum, Brug		U. S. Ex. Ex	1
Dolium fasciatum, Brug			1
Dolium fasciatum, Brug		Gould	3
Dolium costatum, Menke		Gould	3
Dolium costatum, Menke		U. S. Ex. Ex	4
Dolium costatum, Menke., var. maculatum, Lam	Tavoy, Burmah	Gould	4
Dolium costatum, Menke., var. maculatum, Lam			1
Dolium perdix, Linn		Gould	1
Dolium perdix, Linn		U. S. Ex. Ex	3
Subgenus Malea, Val., 1833.			
Dolium pomum, Linn		Gould	6
Dolium pomum, Linn		U. S. Ex. Ex	2
Dolium ringens, Swains		Gould	3
Genus pyrula, Lam., 1799.			
Pyrula reticulata, Lam		Gould	5
Pyrula decussata, Wood		Gould	2
Pyrula decussata, Wood	Mazatlan	Gould	2
Pyrula papyratia, Say	St. Joseph's Bay, Fla	Gould	1
Pyrula papyratia, Say	Georgia	Gould	4

FAMILY DOLIIDÆ — (*Concluded*).

NAME.	Locality.	Collection.	Specimens.
Genus pyrula, Lam., 1799 — (*Concluded*).			
Pyrula papyratia, Say	Apalachicola	Gould	3
Pyrula ficus, Linn		Gould	8
Pyrula Dussumieri, Val	China	Gould	2
Pyrula tessellata, Kobelt	Rosemary Is., Australia	Gould	3

REPORT

OF THE

STATE BOTANIST.

1893.

REPORT.

To the Honorable the Regents of the University of the State of New York:

Gentlemen.— I have the honor of communicating to you the following report:

Specimens of plants to represent the flora of the State in the Herbarium of the State Museum have been collected by the Botanist during the past season in the counties of Albany, Cayuga, Dutchess, Essex, Herkimer, Jefferson, Oneida, Onondaga, Rensselaer, Saratoga, St. Lawrence and Sullivan.

Specimens contributed by correspondents were collected in the counties of Albany, Erie, Essex, Kings, St. Lawrence, Suffolk, Richmond and Tompkins.

Specimens of 261 species of plants have been added to the Herbarium of which 245 were collected by the Botanist and 16 were contributed.

Of the added plants 40 belong to species not before represented therein and of these 11 are deemed new species. The remaining specimens, though not representing species new to the Herbarium, are intended to make more complete and satisfactory the exhibit of the species to which they belong.

A list of the species of which specimens have been added is marked A.

Specimens have been contributed to the Herbarium by 15 contributors. Some of these are plants found beyond our limits but they are valuable for reference, comparison and study. A list of the contributors and of their respective contributions is marked B.

A record of species not before reported, together with their localities, time of collection, descriptions of new species and other matters of interest, also descriptions of a few extralimital species of which specimens were sent for identification, will be found marked C.

A record of observations on species previously reported, remarks concerning them and descriptions of new or peculiar forms or varieties will be found under D. An inspection of this part of the report will show that more attention than usual has been given to the study of the variations in our flowering plants and that there are many deficiencies in the descriptions of the Manual. The study of these variations and their causes is a most interesting one and is not without its practical value. It is necessary to give us a more complete knowledge of the limits and behavior of species and to enable us to write complete and satisfactory descriptions of them. It is noticeable that most of our cultivated plants are very variable. By cultivation, selection, crossing and close pollination the natural variations have been fixed and even intensified so that we have varieties apparently as distinct as species themselves. Differences in soil, climate, degrees of moisture and prevailing temperature appear to be causes of variation in some cases but these external influences are not sufficient to explain all cases of variation. For example in a low strip of land lying along the railroad near Narrowsburg, five distinct forms or varieties of the common racemed loosestrife were found. These, so far as could be ascertained, all grew in the same kind of soil and subject to the same external conditions.

In a single patch of the bland or early wild rose growing near the station at Cooperstown Junction, although the patch was but a few feet in diameter, some of the young shoots have infrastipular spines, but most of them, as usual, were destitute of these spines. What should cause the differences noted in these instances? It is sometimes said that plants have an inherent tendency to vary, but this scarcely enlightens us or gives a satisfactory explanation of the results observed. Even the influence of cross pollination and the action of the laws of heredity do not seem a sufficient or satisfactory explanation in all cases. But whatever the hidden or unknown causes of such variations may be the resulting phenomena are certainly interesting to the student of nature and in the case of useful plants they are not without utility. They indicate a peculiar kind of adaptability in the species to varying conditions of growth and to wider fields of usefulness.

Some special effort has been made to perfect the representation of our native pond weeds in the Herbarium. At the time the State Flora was written by Doctor John Torrey nine species of Potamogeton were recorded as inhabiting New York waters. In the Monograph of the Naiadaceæ of North America recently prepared by Doctor Thomas Morong, 27 New York species are recognized. Of these 26 are now represented in the Herbarium. Some of these species are extremely variable and require many specimens to properly represent them in all their variations. Many forms and varieties new to the Herbarium have been collected, also one species new to the Herbarium and one new to the State. *Potamogeton lucens* var. *Connecticutensis* was discovered by Mr. L. H. Hoysradt in Stissing pond several years ago. This still remains its only known locality in our State. From it specimens of this rare form have been obtained. More typical forms were collected in Oneida and Cayuga lakes where the plants are by no means scarce. A list of the New York species of Potamogeton is given in another part of this report. "The Plains" is a name given to a tract of land lying along the upper waters of the Oswegatchie river in the southern part of St. Lawrence county. Being desirous of observing the character of its vegetation this place was visited. It is destitute of trees with the exception of a few scattered poplars and tamaracks. Clumps of willows and of the common meadow sweet with some mountain fly honeysuckle, an abundance of Canadian blueberry and some choke cherry and choke berry bushes are the principal shrubs. The prickly blackberry, *Rubus setosus*, a northern species, is here and the common wintergreen. Goldenrods were abundant, the Canadian goldenrod prevailing and showing marked variations. The willow-leaved goldenrod, *Solidago uliginosa*, which usually grows in swamps and wet places, here grows on dry sandy soil. A peculiar departure from the ordinary habitat was also noticed in two grasses, the white-grained mountain rice, *Oryzopsis asperifolia*, and the purple wild-oat, *Avena striata*. These usually grow in the shade of trees or in woods, but here both were abundant and growing exposed to the full sunlight. The land of this tract is not level but rises gradually as it recedes from the river, and in some places there are depressions or swales. In these, several species of sedge grow and other plants fond of moist or wet soil. The whole area was strongly suggestive of an old wornout or abandoned farm. There was no evidence of former forest growth on it nor was it clear why trees had not occupied it. One guide claimed that fire had destroyed the timber but I saw no remains of charred trunks to bear out this claim. The indications point rather to poverty of soil as a partial explanation of the absence of forest trees and yet this is evidently not the whole nor a very satisfactory explanation.

The newspapers have recently reported several cases of mushroom poisoning. This emphasizes the importance of a more general and better knowledge of these plants and more care in selecting and eating them. It indicates that the action of the Board of Regents in directing the preparation of life-size colored figures of our edible and poisonous species of fungi and plain and simple descriptions of them was wise and needful. It is very desirable that the appropriation necessary for the publication of these plates and descriptions be made at the coming session of the Legislature. The question is often asked, how shall the edible mushrooms be distinguished from the poisonous or dangerous species. The answer is, there is no simple or peculiar mark or character by which they may be distinguished. It is necessary to know and to be able to recognize each species used for food by its own specific characters. All not known to be safe eating, should be rejected. This is the rule in the case of the higher orders of plants. A considerable number of species are known to be good for food, a few are known to be poisonous, either in root, herbage or fruit and a much larger number, while neither hurtful nor edible, are regarded as either worthless or useful for other than edible purposes. We invariably recognize those used for food by their own specific characters and do not look for any single mark or character by which to distinguish poisonous plants or fruits from edible ones. Sometimes the good and bad are closely related botanically and accidents happen from a failure to recognize specific characters. Thus poison hemlock is sometimes mistaken for sweet cicily, both belonging to the same family and having a similar general appearance. In the Nightshade family or Solonaceæ we find such food plants as the potato, tomato and eggplant associated botanically with such inedible or hurtful species as tobacco, henbane and thorn apple or stramonium. If we would avoid accidents we must know each species so well that no dangerous species will be mistaken for it. So among fungi we find that really excellent esculent, the royal mushroom, often called Cæsar's mushroom, *Amanita cœsarea*, associated not only in the same genus but even in the same group or section with the delusive and deadly phalloid mushroom, *Amanita phalloides.* Both are attractive in appearence, tender in substance and not at all repulsive in taste or odor, but to eat one is health and life, to eat the other is sickness and death.

But the species of fleshy fungi are so numerous and so similar in structure that much greater care is required in discriminating between the good and the bad, than is necessary in the case of flowering plants. It is scarcely to be expected that people generally will acquire sufficient knowledge to enable them to do this in all cases, but all who desire to use these plants as food may easily acquire from faithful figures and simple descriptions a sufficient knowledge to enable them to distinguish the more common and important species. There are at least 75 edible species found in our State, though many of them are rare or seldom seen in abundance. Some are both common and abundant and these may easily become familiar to those interested. In some countries of Europe where mushroom eating is more common than it is here, it has been found expedient to appoint inspectors of the markets whose duty it is to see that no hurtful species is offered for sale. But if people in the country see fit to run the risk of collecting and eating such as are not known to be safe and edible they must suffer the consequences.

There are certain rules that guide the mycologist and the skilled experimenter in estimating the probable character or edibility of untried species, but to these there are so many exceptions that they are not wholly reliable.

One rule is to reject all which are tough leathery or corky in texture. Even in the absence of any deleterious quality they would at least be indigestible. The fairy ring mushroom, *Marasmius oreades*, is an exception to this rule, for though it is rather tough it is often eaten with relish and with proper preparation its toughness is overcome. Some species are tender when young though tough when old. Some tough species may be utilized in making soups or in giving flavor to other dishes.

Another rule says reject all such as have an unpleasant taste or odor in the fresh state. The honey colored mushroom may be cited as an exception to this rule. Its taste is harsh and unpleasant when uncooked, but this is to a great extent removed by proper cooking, and a very good and harmless meal may be made of it. Some species of Lactarius have a very hot, acrid or peppery taste when fresh, but this in some cases may be dispelled by cooking. Even the delicious lactarius and the chantarelle, whose edible qualities are highly commended, are not very pleasant in flavor when fresh.

In some species of Boleti the flesh where bruised or wounded quickly assumes a blue or greenish-blue color. The rule is to avoid all such species as dangerous.

One author counsels avoidance of all such as have pink or flesh-colored spores. An exception to this rule is found in the plum clitopilus, *Clitopilus prunulus*, which is regarded as a very good mushroom, notwithstanding its pink spores.

Even mushrooms which in good condition are palatable and nutritious may become unfit for food and even hurtful by age and decomposition or by becoming water-soaked or infested by the larvæ of insects. Even too long keeping before cooking has been known to make them deleterious. In one instance a large quantity of a species known to be edible was collected. The family made a meal of a part of them the same day. No evil results followed. The remaining part was reserved till the next day, then cooked and eaten. Those partaking of these stale samples were made sick and vomiting ensued. But all except one soon recovered after the rejection of the noxious material. Even the common edible mushroom is said to keep in good condition longer if cooked soon after it is gathered than if left in its raw state.

Several edible species have when fresh a farinaceous or meal-like taste and odor. From this some have drawn the inference that this is a mark of edible species, or at least that all which have this flavor are esculent. But there are many exceptions to this, for some when first tasted have a pleasant farinaceous flavor, which is quickly followed by one that is bitter or otherwise unpleasant.

From all this it will readily be seen how difficult it is to devise any general practical rule by which to separate the esculent from the dangerous species.

Probably the phalloid amanita, *Amanita phalloides*, is the one species above all others that causes the most of the deaths attributed to mushroom poisoning. The cap of this species varies somewhat in color, the form, which is entirely white, being the most common with us and the most often mistaken for the common mushroom. Only gross carelessness, however, could make such a mistake, for in this deleterious toadstool the stem is nearly always much longer proportionately than in the mushroom, it has an abrupt and large bulb at its base which is wanting in the mushroom, and its gills or lame læ on the under surface of the cap are always white, while in the mushroom they are, when young, a beautiful pink or flesh color, but when old this changes to a brown or blackish color.

Considerable time was occupied in the early part of the year, as will be shown by the monthly reports, in preparing an exhibit of specimens of economic fungi for the World's Columbian Exposition. The questions asked me and the remarks of visitors overheard by me while placing this exhibit in position in the Horticultural Building indicate that it may be a valuable part in the Museum's exhibit as an educator of the public. It is composed of 61 species of edible fungi, 63 species of fungi growing on and injurious to wood, 18 species of parasitic fungi which are injurious to cultivated or useful wild plants, and six species that are injurious to noxious weeds and animals, and therefore beneficial to man. A list of the names of these species and varieties is marked E. A preliminary list of Hymenomycetous Fungi inhabiting our principal coniferous trees is marked F.

Respectfully submitted.

CHARLES H. PECK.

Albany, *September* 19, 1893.

(A.)

PLANTS ADDED TO THE HERBARIUM.

New to the Herbarium.

Hieracium Marianum *Willd.*
Polygonum Douglassii *Greene.*
Potamogeton Vaseyi *Robbins.*
P. pulcher *Tuckm.*
P. lucens *L.*
Carex glabra *Boott.*
Panicum miliaceum *L.*
Psathyrella tenera *Pk.*
Hydnum subcarnaceum *Fr.*
Merulius tenuis *Pk.*
M. irpicinus *Pk.*
Stereum populneum *Pk.*
Lepidoderma fulvum *Mass.*
Æcidium Actææ *Opiz.*
Phoma enteroleuca *Sacc.*
Cytospora ambiens *Sacc.*
C. carbonacea *Fr.*
Septomyxa persicina *Sacc.*
Discosia magna *Pk.*
Septoria Pisi *West.*
Septoria Scutellariæ *Thum.*
S. conspicua *E. & M.*
Haplosporella Symphoricarpi *Pk.*
Rhabdospora rhoina *Pk.*
Camarosporium metableticum *Trail.*
Volutella stellata *Pk.*
Epicoccum nigrum *Lk.*
Penicillium candidum *Lk.*
Cercospora tenuis *Pk.*
Cladosporium episphæricum *Schw.*
Zygodesmus granulosus *Pk.*
Peronospora Hydrophylli *Waite.*
Peziza Dudleyi *Pk.*
Exoascus Potentillæ *Sacc.*
Diatrype Hochelagæ *E. & E.*
Sphærella Chimaphilæ *Pk.*
Diaporthe decedens *Fr.*
Massariella Curreyi *Tul.*
Melanconis occulta *Sacc.*
Amphisphæria umbrina *Wint.*

Not New to the Herbarium.

Ranunculus circinatus *Sibth.*
R. septentrionalis *Poir.*
R. Pennsylvanicus *L.*
Coptis trifolia *Salisb.*
Thalictrum purpurascens *L.*
Actæa alba *Bigel.*
Asimina triloba *Dunal.*
Nymphæa reniformis *DC.*
Nuphar advena *Ait.*
Dentaria diphylla *L.*
Cardamine rhomboidea *DC.*
Arabis perfoliata *Lam.*
Nasturtium palustre *DC.*
N. hispidum *DC.*
Hesperis matronalis *L.*
Brassica oleracea *L.*
Raphanus sativus *L.*
Viola Canadensis *L.*
V. rostrata *Pursh.*
Silene stellata *Ait.*
Stellaria media *Sm.*
Ailanthus glandulosus *Desf.*
Acer spicatum *Lam.*
A. saccharinum *Wang.*
Prunus Americanum *Marsh.*
P. Persica *B. & H.*
Rubus Millspaughii *Britton.*
R. Canadensis *L.*
R. hispidus *L.*
Fragaria vesca *L.*
Agrimonia parviflora *Ait.*
Rosa blanda *Ait.*
Saxifraga aizoides *L.*
Tiarella cordifolia *L.*
Mitella diphylla *L.*
Ribes Grossularia *L.*
Myriophyllum spicatum *L.*
Callitriche heterophylla *Pursh.*
Sambucus racemosa *L.*
Galium Aparine *L.*
G. asprellum *Mx.*
G. trifidum *L.*
Solidago uliginosa *Nutt.*
S. juncea *Ait.*

Solidago Canadensis *L.*
Aster macrophyllus *L.*
A. Novi-Belgii *L.*
A. acuminatus *Mx.*
A. nemoralis *Ait.*
Erigeron strigosus *Muhl.*
E. Philadelphicus *L.*
Rudbeckia hirta *L.*
Bidens Beckii *Torr.*
Calendula officinalis *L.*
Anthemis Cotula *DC.*
Achillea Millefolium *L.*
Chrysanthemum Leucanthemum *L.*
Prenanthes Serpentaria *Pursh.*
P. altissima *L.*
Lactuca Canadensis *L.*
L. integrifolia *Bigel.*
Sonchus asper *Vill.*
Campanula aparinoides *Pursh.*
Vaccinium corymbosum *L.*
Rhododendron viscosum *Torr.*
R. maximum *L.*
Primula Mistassinica *Mx.*
Steironema lanceolatum *Gr,*
Lysimachia stricta *Ait.*
L. quadrifolia *L.*
L. Nummularia *L.*
Fraxinus Americana *L.*
F. sambucifolia *Lam.*
Apocynum cannabinum *L.*
A. androsæmifolium *L.*
Asclepias tuberosa *L.*
Gentiana linearis *Frœl.*
Lithospermum officinale *L.*
Physalis lanceolata *Mx.*
Mimulus ringens *L.*
M. moschatus *Dougl.*
Veronica Virginica *L.*
Utricularia vulgaris *L.*
Verbena hastata *L.*
Teucrium Canadense *L.*
Pycnanthemum incanum *Mx.*
Blephilia hirsuta *Benth.*
Brunella vulgaris *L.*
Rumex Patientia *L.*
Polygonum aviculare *L.*
P. amphibium *L.*
Asarum Canadense *L.*
Saururus cernuus *L.*
Dirca palustris *L.*
Pinus Banksiana *Lambert.*
P. resinosa *Ait.*
Picea nigra *Lk.*
P. alba *Lk.*
Larix Americana *Mx.*
Elodea Canadensis *Mx.*
Microstylis monophyllus *Lindl.*
Habenaria bracteata *R. Br.*
Cypripedium acaule *Ait.*
Clintonia borealis *Raf.*
Lilium Canadense *L.*
Pontederia cordata *L.*
Juncus militaris *Bigel.*
Luzula vernalis *DC.*
Typha latifolia *L.*
Potamogeton natans *L.*
P. Nuttallii *C. & S.*
P. Spirillus *Tuckm.*
P. lonchites *Tuckm.*
P. amplifolius *Tuckm.*
P. heterophyllus *Schreb.*
P. prælongus *Wulf.*
P. perfoliatus *L.*
P. crispus *L.*
P. zosteræfolius *Schum.*
P. pusillus *L.*
P. major *Morong.*
P. filiformis *Pers.*
P. pectinatus *L.*
Fimbristylis autumnalis *R. & S.*
Scirpus lacustris *L.*
S. sylvaticus *L.*
Eriophorum lineatum *B. & H.*
E. cyperinum *L.*
E. gracile *Koch.*
Carex tribuloides *Wahl.*
C. cristata *Schw.*
C. fœnea *Willd.*
C. straminea *Willd.*
C. mirabilis *Dew.*
C. siccata *Dew.*
C. bromoides *Schk.*
C. Deweyana *Schw.*
C. trisperma *Dew.*
C. canescens *L.*
C. sterilis *Willd.*
C. Muhlenbergii *Schk.*
C. rosea *Schk.*
C. vulpinoidea *Mx.*
C. stipata *Muhl.*
C. laxiculmis *Schw.*

Carex digitalis *Willd.*
C. laxiflora *Lam.*
C. albursina *Sheldon.*
C. Œderi *Ehrh.*
C. gracillima *Schw.*
C. æstivalis *Curt.*
C. debilis *Mx.*
C. virescens *Muhl.*
C. limosa *L.*
C. torta *Boott.*
C. Houghtonii *Torr.*
C. squarrosa *L.*
C. utriculata *Boott.*
C. oligosperma *Mx.*
C. intumescens *Rudge.*
C. lurida *Wahl.*
C. communis *Bail.*
C. Pennsylvanica *Lam.*
C. longirostris *Torr.*
Panicum latifolium *L.*
P. clandestinum *L.*
Phalaris arundinacea *L.*
Brachyelytrum aristatum *Bv.*
Agrostis alba *L.*
Arrhenatherum avenaceum *Bv.*
Avena striata *Mx.*
Danthonia spicata *Bv.*
D. compressa *Aust.*
Poa annua *L.*
P. compressa *L*
P. debilis *Torr.*
P. serotina *Ehrh.*
Festuca ovina *L.*
F. elatior *L.*
F. nutans *Willd.*
Bromus ciliatus *L.*
B. purgans *L.*
Agropyrum repens *Bv.*
Agropyrum violaceum *Lange.*
Flammula alnicola *Fr.*
Pluteolus expansus *Pk.*
Cortinarius argentatus *Fr.*
Russula uncialis *Pk.*
Cantharellus minor *Pk.*
Coprinus micaceus *Fr.*
Boletus subtomentosus *L.*
Polyporus resinosus *Fr.*
P. salicinus *Fr.*
Poria radiculosa *Pk.*
Porothelium fimbriatum *Fr.*
Corticium incarnatum *Fr.*
C. subaurantiacum *Pk.*
Entomosporium maculatum *Lev.*
Chrysomyxa Pyrolæ *Rostr.*
Ustilago anomala *Kze.*
Sphacelotheca Hydropiperis *DeBy.*
Uromyces Limonii *Lev.*
U. Trifolii *Lev.*
U. Polygoni *Fckl.*
U. Euphorbiæ *C. & P.*
Puccinia Galii *Schw.*
Sphæropsis malorum *Pk.*
Vermicularia liliacearum *Schw.*
Coryneum microstictum *B. & Br.*
Peridermium balsameum *Pk.*
Actinonema Rosæ *Fr.*
Cystopus candidus *Lev.*
C. spinulosus *DeBy.*
C. Amaranthi *Berk.*
Ramularia Armoraciæ *Fckl.*
Fusarium oxysporum *Schl.*
Diatrype virescens *Schw.*
Hypoxylon perforatum *Schw.*
H. atropurpureum *Fr.*
Plowrightia morbosa *Sacc.*
Urocystis Waldsteiniæ *Pk.*

(B)

CONTRIBUTORS AND THEIR CONTRIBUTIONS.

Mrs. E. G. Britton, New York, N. Y.

Ephemerum crassinervium *Hampe.*
Rhabdoweisia denticulata *B. & S.*
Dicranella heteromalla *Schp.*
Dicranum fulvum *Hook.*
D. flagellare *Hedw.*
D. longifolium *Hedw.*
D. viride *Schp.*
Dicranum fulvellum *Sm.*
D. Sauteri *Sch.*
Cynodontium gracilescens *Schp.*
C. virens *Schp.*
Dicranodontium longirostre *B. & S.*
Didymodon cylindricus *B. & S.*
Barbula tortuosa *W. & M.*

Trichostomum vaginans *Sulliv.*
Blindia acuta *B. & S.*
Ulota crispa *Brid.*
Grimmia conferta *Fnck.*
Racomitrium microcarpum *Brid.*
R. fasciculare *Brid.*
Anacamptodon splachnoides *Brid.*
Aulacomnium palustre *Schwægr.*
Anomodon apiculatus *B. & S.*
Homalia trichomanoides *B. & S.*
Neckera oligocarpa *B. & S.*
Eurhynchium strigosum *B. & S.*
Plagiothecium denticulatum *B. & S.*
Limnobium montanum *Wils.*
L. eugyrium *Schp.*
L. ochraceum *B. & S.*
Hypnum reptile *Mx.*
H. umbratum *Ehrh.*
H. strigosum *Hoffm.*
Rhynchostegium Jamesii *Sulliv.*

Mrs. P. H. Dudley, New York, N. Y.

Chondrus crispus *Lyng.*

Mrs. E. C. Anthony, Gouverneur, N. Y.

Rudbeckia hirta *L.*

Rev. J. L. Zabriskie, Flatbush, N. Y.

Nostoc sphæricum *Vauch.*
Vollutella stellata *Pk.*
Zygodesmus granulosus *Pk.*

George Green, Katonah, N. Y.

Cladosporium fulvum *Cke.*

S. M. Tracy, Agricultural College, Miss.

Cerebella Paspali *C. & M.*
C. Andropogonis *Ces.*
Cerebella Spartinæ *E. & E.*
Cercospora personata *B. & C.*

R. B. Hough, Lowville, N. Y.

Pinus inops *Ait.*

C. L. Shear, Alcove, N. Y.

Carex debilis *Mx.*
Solenia anomala *Pers.*
Haplosporella Symphoricarpi *Pk.*
Diatrype Hochelagæ *E. & E.*
Melanconis occulta *Sacc.*

Smith Ely Jeliffe, M. D., Brooklyn, N. Y.

Camarosporium metableticum *Trail.*
Amphisphæria umbrina *Wint.*

William Herbst, M. D.

Queletia mirabilis *Fr.*

N. Ringuenberg, M. D., Lockport, N. Y.

Asimina triloba *Dunal.*

L. H. Hoysradt, Pine Plains, N. Y.

Carex arcta *Boott.*
C. glabra *Boott.*
C. stenolepis *Torr.*
C. bullata *Schk.*
Lycopodium alopecuroides *L.*
L. Carolinianum *L.*
Asplenium viride *Huds.*

E. S. Miller, Floral Park, N. Y.

Potamogeton pulcher *Tuckm.*

B. D. Halsted, New Brunswick, N. J.

Exobasidium Peckii *Halst.*

W. R. Dudley, Palo Alto, Cal.

Hydnum subcarnaceum *Fr.*
Merulius irpicinus *Pk.*
M. tenuis *Pk.*
Lepidoderma fulvum *Mass.*
Polyporus versicolor *Fr.*
Penicillium candidum *Lk.*
Peziza Dudleyi *Pk.*
Gyromitra sphaerospora *Sacc.*
Dædalea unicolor *Fr.*

(C.)

SPECIES NOT BEFORE REPORTED.

Ranunculus hispidus *Mx.*

North Greenbush. May. This is included, in the New York State Flora, with *Ranunculus repens* as variety *Marilandicus*, but it is now regarded by good botanists as a distinct species. It is one of our earliest flowering buttercups.

Aster leiophyllus *Porter.*

Lake Mohonk and Shokan, Ulster county. Sept. This beautiful aster was at first described by Professor Porter under the name *Aster cordifolius* var. *lævigatus*, but having concluded that it is a distinct species, he has published it as such under the name here given. It certainly appears to me to be a good species easily distinguished from *A. cordifolius* both by the character of its leaves and of its flowers.

Senecio Robbinsii *Oakes.*

Rocky banks of Black river below Brownsville. June. This plant is *Senecio aureus* var. *Balsamitæ* of the Manual, but it has recently been raised to specific rank, a position which, in my opinion, it justly merits. According to Dr. Rusby's description, the typical form of the species is two to three feet high, glabrous, with the root leaves sharply and unequally serrate. In our specimens the root leaves are crenately serrate, the plants are one to two feet high and show a cotton-like tomentum at the insertion of the leaves and also, under a lens, a minute loose tomentum on the leaves and stems and at the base of the involucres. The peduncles originate at nearly the same point at the top of the stem, giving to the corymb an umbellate appearance. In consequence of these variations from the type I would designate our plant as var. *subtomentosus*. Unlike the typical form our plant grew in thin dry soil covering rocks. It was partly shaded by trees.

Hieracium Marianum *Willd.*

Highland lake, Sullivan county. July. Rare.

Polygonum Douglassii *Greene.*

Rocky summit of Cobble hill near Elizabethtown, Essex county. September.

This was formerly referred to *P. tenue*, but it is easily distinguished from that species by its drooping fruit.

Potamogeton Vaseyi *Robbins.*

Thompson's lake, Albany county. August. Dr. Morong finds it in Greenwood lake, Orange county.

In general appearance it resembles *P. diversifolius*, from which it is easily separated by its larger fruit with the middle keel rounded.

Potamogeton pulcher *Tuckm.*

Riverhead, Suffolk county. *E. S. Miller.* Rare.

Potamogeton major (*Fr.*) *Morong.*

Cayuga and Seneca lakes. August. This is *P. pusillus* of the State Flora where it is credited to Crooked lake on the authority of Dr. Sartwell. In the Manuals it stands as *P. pusillus* var. *major* and *P. mucronatus.* I follow Dr. Morong in considering it a good species and I have adopted the name under which he publishes it.

Carex glabra *Boott.*

Taberg, Oneida county, and Cooperstown Junction, Otsego county. June. In the Taberg station it was growing in the midst of a patch of *C. debilis.* Its heavier spikes and different appearance at once attracted attention.

Carex albursina *Sheldon.*

This plant has been considered a variety of *C. laxiflora* and is subjoined to that species as var. *latifolia* in the Manual. But it is so constant in its characters and so easily separated from all forms of *C. laxiflora*, by its broad bracts and short inconspicuous staminate spike that I can readily admit its claims to specific rank. We have it from the Helderberg mountains and from Sanfords Corners, Jefferson county. June.

Panicum miliaceum *L.*

Port Jervis and Albany. July. This millet has been introduced and is frequently found growing in waste places about cities and villages. Prof. Dudley reports it at Ithaca, and Dr. Howe at Lansingburgh and in various places in the valley of the lower Hudson.

Psathyrella tenera *n. sp.*

Pileus thin, campanulate, obtuse, moist or subhygrophanous reddish-cinereous when moist, paler when dry, slightly rugulose and atomate; lamellæ broad, adnate, plane or but slightly ascending, subdistant, at first pallid or subcinereous, then umber and finally blackish, white on the edge; stem slender, glabrous, stuffed or hollow, white, with a white floccose mycelium at the base; spores narrowly elliptical, .0005 to .00055 in. long, .0003 broad.

Pileus 3 to 5 lines broad; stem 1 to 1.5 in. long, scarcely half a line thick.

Damp mucky ground in open woods. Pierrepont Manor, Jefferson county. June.

This plant resembles small forms of *Galera tenera* in color and shape, but it is readily distinguished from that species by the darker color of the mature lamellæ and of the spores. The plant is much smaller than *P. gracilis* and *P. graciloides* to which it seems to be related.

Hydnum subcarnaceum *Fr.*

Decayed wood. Ithaca. *Prof. W. R. Dudley.*

Merulius irpicinus *n. sp.*

Resupinate, thin, soft, more or less tomentose beneath, whitish, the margin sometimes free or slightly reflexed; hymenium at first gyrose porose, the dissepiments at length prolonged into subulate or irpex-like teeth, subferruginous; spores subglobose or elliptical, colored, .0002 to .00028 in. long, .00016 to .0002 broad.

Decaying wood. Ithaca. October. *Dudley.*

This species resembles *M. lacrymans* in habit and color, but it is thinner and more fragile, with smaller pores and spores, and it is especially distinguished by the elongated or subulate teeth that project from the older parts of the hymenium. It is referable to the section Coniophori.

Merulius tenuis *n. sp.*

Resupinate, very thin, tender, reddish-brown inclining to liver color, the margin webby-tomentose, whitish; dissepiments narrow, irregular, forming shallow unequal pores; spores colored, .00035 to .0004 in. long, .00025 to .0003 broad.

Much decayed wood. Ithaca. *Dudley.*

The color of the dried specimens resembles that of Persoon's figure of *M. pulcher*, but the dissepiments and pores are different. This species also is referable to the section Coniophori.

Stereum populneum *n. sp.*

Resupinate, very thin, orbicular, often confluent in patches, minutely rimose, brown tinged with liver color, minutely whitish-punctate under a lens, the thin radiate-dentate margin a little paler, at length becoming more or less free; spores oblong, .0005 to .0006 in. long, .00016 broad.

Bark of prostrate trunks of poplar, *Populus tremuloides*. Adirondack mountains. August.

This is distinct from all allied species by its peculiar color, its minutely chinky and punctate hymenium and its subfree dentate margin.

It is related to *S. albobadium*.

Stereum ambiguum *n. sp.*

Resupinate, suborbicular or irregular, soon confluent in patches, one-half to one line thick, dry, subcorky but brittle, tawny-brown and subtomentose beneath; the hymenium tawny-brown becoming paler or grayish tawny with age, rimose when mature, with a faintly pulverulent or pruinose-velvety appearance; the margin yellowish, generally becoming free; spores oblong or subfusiform, .0005 to .0007 in. long, .0002 broad.

Wood and bark of prostrate trunks of spruce, *Picea nigra*. Adirondack mountains. June.

This singular species is apparently related to *Stereum abietinum*, to which it was formerly referred, but from which it was seen to be distinct when the spore characters of that species were published.

The thick interior stratum is similar in color to the hymenium and appears to be composed of densely compacted erect fibrils. The hymenium, under a lens, is seen to possess both setæ and metuloids, thus combining the characters of the genera Hymenochæte and Peniophora, and obliterating the distinction of these as *Dædalea confragosa*, in its various forms, destroys the distinction between Trametes and Lenzites. Moreover when these setæ and metuloids are more highly magnified they are found to vary among themselves, being sometimes smooth and sometimes warted, acute or blunt, colored or colorless, and sometimes even partly colored and smooth and partly colorless and warted.

Also the hymenium, though dry and firm in texture, becomes rimose as in many of the species of Corticium with a soft and waxy hymenium.

Lepidoderma fulvum *Mass.*

Decayed wood. Ithaca. *Dudley.*

This is a small form scarcely one line high. The scales of the peridium are white, the few large spores intermingled with those of the prevailing size are .0007 to .0008 in. broad, and the slender threads of the capillitium are sometimes furnished with thickenings as in those of *L. tigrinum.* The plants grow either singly or in groups of three to five.

Æcidium Actææ *Opiz.*

Living leaves of baneberry, *Actæa spicata* v. *rubra.* Adams, Jefferson county. June.

Phoma enteroleuca *Sacc.*

Decorticated branches of apple tree. Bethlehem, Albany county. May.

Our specimens differ from the typical form in growing on decorticated branches and in having the spores slightly broader.

Cytospora ambiens *Sacc.*

Dead stems of raspberry, *Rubus strigosus.* Menands, Albany county. April.

Cytospora carbonacea *Fr.*

Dead branches of elm, *Ulmus Americana.* Elizabethtown. May.

The mass of ejected spores is black when dry.

Septomyxa persicina (*Fres*) *Sacc.*

Rind of squashes. Menands. January.

Var. **nigricans** *n. var.* Forming large irregular black patches; heaps minute; spores oblong, rounded at each end, more or less narrowed in the middle, often two to four-nucleate, colorless, .0003 to .0005 in. long, .00012 to .00016 broad, oozing out and forming a pale wine colored or peach-colored tendril or mass.

Discosia magna *n. sp.*

Perithecia gregarious, suborbicular, large, .014 to .024 in. broad, black, opaque, even or obsoletely rugulose, ostiolate, rarely confluent; spores oblong-fusoid, curved, obscurely two to three-septate, .0005 to .0008 in. long, the bristle at each end .0004 to .0005 in. long.

Fallen fruit of ash, *Fraxinus Americana.* Elizabethtown. May.

The species is easily known by its large opaque perithecia and simple or obscurely septate spores.

Septoria Pisi. *West.*

Living pea leaves. Adirondack mountains. August.

Septoria Scutellariæ *Thum.*

Living leaves of scull-cap, *Scutellaria galericulata.* Adirondack mountains. July.

Septoria conspicua *E. & M.*

Living leaves of fringed loosestrife, *Steironema ciliatum.* Long Island. July.

Haplosporella Symphoricarpi *n. sp.*

Stroma small .02 to .06 in. broad, often confluent, erumpent, suborbicular, closely surrounded by the ruptured remains of the epidermis, black, the upper surface plane or slightly convex, dotted by the slightly prominent ostiola; spores oblong, colored, continuous, .0006 to .0008 in. long, .0003 broad.

Dead stems of snowberry, *Symphoricarpus racemosus.* Alcove, Albany county. March. *C. L. Shear.*

Rhabdospora rhoina *n. sp.*

Perithecia numerous, sunk in the bark, covered by the slightly pustulated epidermis; spores subfiliform, slender, curved, .0005 to .0006 in. long, oozing out and forming slender yellowish or pallid tendrils.

Dead branches of sumac, *Rhus typhina.* Cooperstown Junction. June.

Volutella stellata *n. sp.*

Sporodochia minute, sometimes confluent in irregular masses which are one to two lines long, covered by the mostly stellately branched brownish-tawny setæ; spores globose or subelliptical, .00016 to .0002 in. long.

Much decayed wood of chestnut. Flatbush. September. *Rev. J. L. Zabriskie.*

This is a peculiar and somewhat aberrant species but it appears to be connected with normal forms by *V. ochracea.* The setæ are variable in length and in ramification. Some are simply dichotomous, others are stellate below and dichotomous above.

Epicoccum nigrum *Lk.*

Dead stems of blackberry lily, *Balamcanda Chinensis.* Menands. May.

Penicillium candidum *Lk.*

On mushrooms, *Agaricus campester*, in a greenhouse. Ithaca. *Dudley.*

Var. *subcandidum.* Fertile hyphæ irregularly branched above, the color at first white, then whitish or cinereous.

Cercospora tenuis *n. sp.*

Spots large, sometimes discoloring the whole leaf, reddish brown; hyphæ fasciculate, short, .0016 in. long, .00016 broad, colored, obscurely septate, the tufts appearing like minute black dots on the upper surface of the leaf; spores very slender, gradually tapering to the apex, continuous or with one to three septa, hyaline, .0016 to .0024 in. long.

Living leaves of hairy bedstraw, *Galium pilosum.* Riverhead. July.

The species is quite distinct from *C. Galii.*

Cladosporium episphærium *Schw.*

On *Daldinia concentrica.* Elizabethtown. May.

Zygodesmus granulosus *Pk.*

Decayed wood of chestnut. Flatbush. August. *Zabriskie.*

Peronospora Hydrophylli *Waite.*

Living leaves of Virginian waterleaf, *Hydrophyllum Virginicum.* Bergen, Genesee county. June.

Peziza Dudleyi *n. sp.*

Cups irregular, one to two inches broad, sessile, externally with a minute appressed white tomentum; hymenium bright yellow inclining to saffron or orange, often rimulose; asci cylindrical; spores oblong, even, binucleate, somewhat granular within, .001 to .0012 in. long, .0005 to .0006 broad; paraphyses filiform, slightly thickened at the tips.

Ground and decayed wood. Ithaca. October. *Dudley.*

This fungus appears to be related to such species as *P. aurantia* and *P. inæqualis*, from both of which it is at once distinguished by its yellow hymenium and larger spores.

Exoascus Potentillæ *Sacc.*

Living leaves of cinquefoil, *Potentilla Canadensis.* Cooperstown Junction. June. Middle Grove. July.

This fungus produces greenish-yellow spots on the leaves. These spots are usually convex above, concave below.

Diatrype albopruinosa *Schw.*

Dead branches of oak, maple, hop hornbean, etc. Albany and Rensselaer counties.

Diatrype Hochelagæ *E. & E.*

Decayed wood. Alcove. January. *Shear.*

Sphærella Chimaphilæ *n. sp.*

Perithecia minute, .0025 to .003 in. broad, numerous, mostly hypophyllous, seated on indefinite blackish spots or occupying the whole surface of the leaf; asci subcylindrical, .0016 to .002 in. long; spores crowded in the ascus, subclavate, colorless, .0005 to .0006 in. long, .00016 broad.

Dead and fallen leaves of Princes Pine, *Chimaphila umbellata.* Cooperstown Junction. June. The septum of the spore is obscure.

Diaporthe decedens *Fr.*

Dead stems of hazelnut. Elizabethtown. May.

Massariella Curreyi *Tul.*

Dead branches of basswood, *Tilia Americana.* Selkirk, Albany county. June.

Our specimens are not typical, but may be called Var. *Americana.* Asci very variable in length, .007 to .009 in. long; spores .0016 to .002 in. long; .0005 to .0006 broad.

Melanconis occulta (*Fckl.*) *Sacc.*

Dead branches of poplar. Alcove. *Shear.*

The following species and varieties are described from extra-limital specimens sent to me for identification and are not known to belong to our State Flora.

Clavaria Macouni *n. sp.*

Clubs single or clustered, 6 to 10 lines high, obtuse or subacute, dingy greenish-yellow or pale-cinereous; spores minute, elliptical, .0002 in. long, .00012 broad.

Among mosses under cedar trees. Canada. September. *Macoun.*

The species belongs to the section Syncoryne.

Clavaria muscoides *L.* var. **obtusa** *n. var.*

Tips of the ultimate branches obtuse. Otherwise like the type. Under cedar trees. Canada. September. *Macoun.*

Hypochnus subviolaceus *n. sp.*

Effused, very thin, floccose-membranaceous, adnate, violet-gray, whitish on the margin; spores subglobose, nearly hyaline, .0002 to .00024 in. broad.

Dead decorticated wood. Canada. September. *Macoun.*

Leptothyrium Spartinæ *n. sp.*

Perithecia minute, depressed, suborbicular elliptical or oblong, sometimes subconfluent in series, rugulose, black, brownish on the margin, easily separable from the matrix; spores narrowly elliptical, subacute, hyaline, .0005 to .0006 in. long, .0002 to .0003 broad, usually containing a single large nucleus, adorned with a filiform appendage at each end.

Dead stems of *Spartina juncea.* Biloxi, Mississippi. September. Number 1835. *S. M. Tracy.*

This is a very distinct species and one that departs from the usual characters of the members of the genus, in its large spores and their filiform appendages. These are sometimes longer than the spore itself. The thin margins of the perithecia have a radiate structure.

Ceratium hydnoides *A. & S.* var. **ramossissimum** *n. var.*

Stromata very numerous, forming patches and dividing above into exceedingly numerous slender snow-white branches which interlace with each other and with those of neighboring stromata and thus form continuous masses.

Var. **subreticulatum** *n. var.* Stromata creeping or ascending, pure white, sparingly branched and uniting with each other in a somewhat reticulate manner.

Both varieties grow on soft much decayed wood. They have a very different appearance but the character of the spores is the same in both and indicates a merely varietal difference.

Canada. *Macoun.*

Zygodesmus tenuissimus *n. sp.*

Effused, pulverulent, very thin, yellowish-gray or subcinereous, the concolorous margin indefinite; the hyphæ short, septate, equalling or exceeding the spore in diameter; spores globose, spinulose, slightly colored, .0003 in. broad.

Decayed wood. Canada. September. *Macoun.*

The species appears to be related to *Z. marginatus* from which it is separable by its thin pulverulent character, short hyphæ and concolorous indefinite margin.

Asterula Tracyi *n. sp.*

Subiculum thin, hypophyllous, composed of slender flexuous septate colored filaments about .00016 in. thick; perithecia very minute, .004 to .005 in. broad, hemispherical or depressed, subastomous, black; asci oblong-clavate, .0011 to .0014 in. long, .0003 to .0004 broad; spores oblong, slightly narrowed toward one end, obscurely 2-to 4-nucleate, colorless, .0003 to .0004 in. long, .00012 to 00015 broad.

Living or languishing leaves of *Spermacoce parviflora.* Biloxi, Miss. August. Number 1842. *Tracy.*

Melogramma effusum *n. sp.*

Stroma effused, thin, superficial, black; perithecia minute, carbonaceous, crowded, convex, opaque, black, white within; asci subcylindrical; spores subfusiform, generally slightly curved, colorless, triseptate, .0008 to .0011 in. long, .00016 to .0002 broad, the second cell usually swollen.

Decayed wood. Canada. *Macoun.*

This species does not harmonize well with the character of the genus to which it is here referred, for the spores in this genus are typically colored. The colorless spores indicate relationship to the genus Zignoella, but the presence of a stroma, which with the perithecia forms a thin rugose carbonaceous crust, shows its relationship to the genus Melogramma and forbids its reference to Zignoella.

Stereum balsameum *Pk.* form **reflexum.**

Pileus coriaceous, firm when dry, villose-tomentose, obscurely zonate; hymenium smoky-purplish, changing to red where wounded.

Canada. *Macoun.*

(D.)

REMARKS AND OBSERVATIONS.

Anemone Virginiana *L.* var. alba *Wood.*

This variety is common in the hilly parts of Sullivan county, where it is the prevailing form. It sometimes forms patches of considerable extent. It does not, so far as I have seen, mingle with the typical form and I am disposed to think that it is a good variety.

Ranunculus circinatus *Sibth.*

Fine specimens of this water crowfoot were obtained in Cayuga lake. The peduncles become deflexed or curved downwards in fruit.

Silene stellata *Ait.*

A form of this plant occurs near Narrowsburg, Sullivan county, in which all the leaves, or all except those of a single whorl, are opposite. It is not uncommon to find a few of the uppermost and of the lowest ones opposite, but this form is apparently rare. Another form has the leaves beautifully crisped or undulate on the margin.

Prunus Americana *Marsh.*

The flowers of this native plum are usually white. A form occurs near Meadowdale, Albany county, and near Westport, Essex county, in which they have the rosy hue of peach blossoms. It might be called variety *rosea.*

Rubus Canadensis *L.*

This low blackberry or dewberry is capable of adapting itself to a great variety of soils and circumstances. These sometimes affect its mode of growth. Plants were found growing among bushes in low swampy ground near Pine Plains, Dutchess county, in which the stem was quite as erect as in *Rubus villosus.* I have indicated in a previous report that whenever, through poverty of soil or for other reasons the prickly stemmed species of Rubus are unable to develop fully or grow freely this starved condition is shown by the failure of the prickles. The same thing has been observed to be the result of an attack of raspberry rust, *Cæoma nitens*, both in the dewberry and the blackberry. Plants badly infested by this rust are generally destitute of prickles.

Rubus setosus *Bigel.*

This northern species occurs in the open region known as "The Plains." This is in the southern part of St. Lawrence county near the headwaters of the Oswegatchie river.

Agrimonia parviflora *Ait.*

Pine Plains. The plants were not yet in flower early in August.

Rosa blanda *Ait.*

The variability of our native roses is the source of considerable difficulty and perplexity in their classification. In the last edition of the Manual this species is said to have no infrastipular spines, yet in a specimen collected at Cooperstown Junction these are plainly present. The stipules are described as dilated, but in another specimen from the same locality, they are very narrow. The fruit is described as globose, but in specimens collected at Thompson's lake, the fruit is pointed at the base and somewhat pyriform. In these specimens also the stipules are very narrow, even on young shoots.

Ribes Grossularia *L.*

Bethlehem. May. An introduced species and escaped from cultivation.

Saxifraga aizoides *L.*

Nearly thirty years ago this plant and its companion, *Primula Mistassinica*, were discovered by Rev. J. A. Paine on the wet and dripping precipices that lie along Fish creek, above Taberg. Both these plants are still abundant in that locality, and the nature of the place is such that nothing but the greed of botanists is likely soon to exterminate them. The yellow saxifrage is especially luxuriant, and often exceeds the dimensions attributed to it in the Manual. It is in flower when the primula is developing its fruit.

Drosera rotundifolia *L.*

This pretty little sundew is common in the Adirondack region. A favorite habitat of it is on decaying trunks of trees lying in the water of lakes and ponds.

Solidago uliginosa *Nutt.*

This pretty goldenrod is common in the Adirondack region. It usually inhabits bogs, marshes or wet places, but sometimes it is found growing in dry soil. It grows in such soil on "The Plains" and on the banks of the upper Oswegatchie river.

Solidago juncea *Ait.*

Though described in the Manual as "smooth throughout," a form occurs on the Helderberg mountains in which the stem and branches are distinctly, though somewhat sparsely, hairy. This is the earliest in flower of the goldenrods about Albany.

Solidago Canadensis *L.*

A form is common on "The Plains" in which the stem is but slightly hairy and the leaves are nearly smooth. They are either sharply serrate or almost entire. This form makes a close approach to *S. serotina.*

Aster nemoralis *Ait.*

Several years ago a single specimen of this neat little aster was brought me by Judge Addison Brown, of New York, who collected it near Hitchings Pond. Recently, fine specimens were collected by myself on the marshy borders of one of the "Five Ponds" in the northern part of Herkimer county. The heads of flowers are large for the size of the plant and vary in number from one to seven in the specimens collected. There was also found on the rocky shore of this pond, near its outlet, a patch of a much larger form of this aster, for which I propose the name variety *major.* Stem one and a half to two feet high; heads of flowers, ten to thirty; leaves larger, two and a half to three inches long, five to seven lines broad, distantly dentate-serrate.

This variety grows in patches, but the typical form, so far as I have observed it, is scattered. In both forms the lower surface of the leaves is minutely resinous or glandular-puberulent, although this character is not noticed in the description of the Manual. The plants in press stick slightly to the drying papers because of this character. This aster occurs also in a marsh near Jayville. It appears thus far to be limited in its range to the northwestern part of the Adirondack region.

Rudbeckia hirta *L.*

A form with the lower half of the rays of a beautiful brown color occurs near Middle Grove. Mrs. Anthony sends the same form from Gouverneur.

Erigeron Philadelphicus *L.*

This handsome fleabane often grows from the crevices of wet shaded or dripping cliffs.

Tragopogon pratensis *L.*

The goatsbeard has been introduced into this country from Europe and is becoming more common each year. It is already beginning to assert itself as a troublesome weed, and those interested should carefully guard their fields and prevent its obtaining a foothold in them. It closely resembles the oyster plant, which sometimes escapes from cultivation, but which seems to be much less common and aggressive. The oyster plant has purple flowers, the goatsbeard, yellow flowers.

Hieracium præaltum *Vill.*

This troublesome weed is gradually extending its range southward. It was observed the past summer at Pierrepont Manor. It has also followed the Carthage and Adirondack railroad eastward and is now found at Jayville. It would be well if farmers would make a special effort to keep this weed in check and also its near relative, the orange hawkweed, *Hieracium aurantiacum.* They are similar in habit and appearance, but one has a yellow flower, the other an orange or reddish blossom. This one is known in some localities as "red daisy." Both form dense patches and spread readily by seed which is easily wafted by the wind by reason of the cottony plumes.

Rhododendron viscosum *Torr.*

This beautiful azalea is abundant about Highland lake, Sullivan county. A single plant was found in which the flowers were as bright and rosy as those of *Rhododendron nudiflorum.* Nearly all the plants have white flowers.

Rhododendron maximum *L.*

This showy shrub grows in great profusion about Barryville and in other places in Sullivan county. The spots in the upper side of the corolla are described as yellow, reddish or orange, but in the Sullivan county plants they appear to me to be constantly green. It may be designated form *viridimaculatum.*

Lysimachia nummularia *L.*

Near Brewerton, Onondaga county, the moneywort has become so well established that it forms extensive carpets over the ground and extends for a considerable distance in the damp woods that skirt the outlet of Oneida lake.

Lysimachia quadrifolia *L.*

At Highland lake a form occurs in which the petals are tipped or margined with orange. The leaves are commonly in whorls of five or six. I have labeled it variety *variegata*, though perhaps it should be considered a form, rather than a variety.

Lysimachia stricta *Ait.*

This loosestrife is very variable. In a small swale near Narrowsburg five forms or varieties of it were collected. The typical form has the leaves lanceolate, opposite and acute at both ends and a rather long and closely flowered raceme with minute subulate inconspicuous bracts. Two varieties have been designated; one, var. *producta*, which has a long loose raceme with conspicuous foliaceous bracts; the other, var. *angustifolia*, which has the leaves narrowly lanceolate or linear and only one or two lines broad, the raceme being rather few flowered.

In the locality mentioned, the typical form, the variety *producta*, a form near var. *angustifolia* and a ternately leaved form of the first two were found growing together and apparently under the same conditions. What should cause these variations?

The narrow leaved form differs from variety *angustifolia* in having the leaves two to three lines broad, instead of one or two lines, and the raceme with numerous flowers. It is therefore intermediate between variety *angustifolia* and the typical form. I call it form *intermedia.*

Commonly the leaves in the typical form are two inches or more in length, but there is a form in which they are less than two inches long. In these short leaved forms the raceme and the pedicels are generally shorter than in the type and the leaves are somewhat blunt at the apex. This might be called form *brevifolia.* The form which bears bulblets in the axils of the leaves and which is generally without flowers might be designated as form *bulbifera.* All of these forms and varieties may have the stem either simple or branched. All of them except variety *angustifolia*, which is found in the Southern States, occur in our State.

The following synopsis will show at a glance the distinctive features here noticed.

Flowers in a loose raceme, bracts subulate, inconspicuous....................................	1
Flowers in a loose raceme, bracts foliaceous, conspicuous....................................	Var. producta
Flowers usually wanting, bulblets in the axils of the leaves....................................	Form *bulbifera*
1 Leaves lanceolate..............................	2
1 Leaves narrowly lanceolate or linear.............	3
2 Leaves two inches or more in length. (L. stricta).	Form *typica*
2 Leaves less than two inches in length	Form *brevifolia*
3 Leaves one to two lines broad, raceme few flowered,	Var. angustifolia
3 Leaves two to three lines broad, raceme many flowered	Form *intermedia*

Steironema lanceolatum *Gr.*

Port Jervis. July. In the Flora of North America the leaves of this species are said to be "an inch or two long." In all the specimens that I have seen they are longer than this, averaging about three inches.

Campanula aparinoides *Pursh.*

Highland lake. A form with pale blue flowers.

Apocynum androsæmifolium *L.*

Narrowsburg. July. A form *pauciflora*, with flowers smaller and whiter than usual. I do not find this form mentioned in our botanies.

Apocynum cannabinum *L.*

The Indian hemp is very abundant along the Delaware river at Port Jervis and at Narrowsburg. It is often procumbent or spreading in its mode of growth.

Var. *hypericifolium* was collected at Narrowsburg.

Asclepias tuberosa *L.*

Port Jervis. The form with yellow flowers.

Mimulus moschatus *Dougl.*

This plant is native in the Pacific coast States and has probably been introduced here because of its musk-like odor. It was found in a bog near Locust Grove, Long Island, in 1886, by J. A. Bixby. In 1891 it was discovered in a swampy locality near Middle Grove, Saratoga county by Rev. J. H. Wibbe. It still exists in this station and is apparently permanently established. It was also reported to me as being well established in two other stations in Saratoga county; one on the farm of T. H. Fuller, two miles southwest of Middle Grove, and the other on the farm of Robert Morris near Greenfield Center.

Utricularia vulgaris *L.*

This bladder wort makes a luxuriant growth in Cayuga lake. Specimens were obtained there having scapes nearly two feet long and 12 to 16 flowered.

Blephilia hirsuta *Benth.*

Taberg. June. A form with white flowers.

Rumex Patientia *L.*

Pierrepont Manor and Middle Grove. A form of this species with leaves closely resembling those of the yellow dock, *R. crispus*, is becoming quite common. Its whitish root more dense panicles and the larger nearly grainless valves of the fruit easily distinguish it. I have not seen the form described in the Manual, and credited with root leaves two to three feet long.

Larix Americana *Mx.*

On the shore of Highland lake an interesting tree of this species was observed. All the cones on the tree had the edges of the cone scales incurved in such a way as to give to each scale a globular shape and to expose to view the bracts of the cone. The cone itself presented an appearance which might be compared to a mulberry or blackberry with very large drupelets. Other trees standing near had cones on them of the usual form. There was no appearance of injury to the cones by insects nor by any other agencies. While this may not be a permanent variety, perhaps a mere sport only, for the sake of convenience I designate it as variety *incurva*.

Picea alba *Lk.*

The white spruce is much less frequent in the Adirondack region than the black spruce. I have observed it in Essex county only. It is a handsome tree though generally of small size, branching nearly or quite to the base, and consequently not of much value for timber. There is, however, a large tree on the northern slope of Raven hill, standing near the road between Elizabethtown and Wadhams Mills. It is about two feet in diameter at the base but its branches extend nearly to the ground. The resemblance between the white spruce and some forms of the black spruce is so close that it is not always easy for an unskilled person to separate them. The descriptions of these trees, as given in the Manual, indicate but a part of their distinctive features, and the characters there ascribed to the edges of the cone scales do not in all cases hold good. Having compared these trees at flowering time the following characters seem to me to be the most available ones for distinguishing them.

White Spruce.	Black Spruce.
Young branchlets glabrous. Leaves six to eight lines long. Cones oblong or cylindrical, deciduous before next flowering time. Sterile aments pale, supported on slender whitish pedicels exserted from the basal cup of scales. Fertile aments eight to ten lines long. Young leaves visible at flowering time.	Young branchlets pubescent. Leaves four to seven lines long. Cones ovate or oblong, still on the tree at next flowering time. Sterile aments tinged with red, sessile in the basal cup of scales. Fertile aments five to six lines long. Young leaves not yet visible at flowering time.

These trees are in flower at the same time in the same locality. They were in bloom the past season in the vicinity of Elizabethtown the last week in May.

Microstylis monophyllos *Lindl.*

Up to this time, fruiting specimens only have represented this very rare and delicate little orchidaceous plant in the State Herbarium. Two flowering specimens were found in June near Taberg.

Clintonia borealis *Raf.*

Form *lateralis.* Like the typical form except in having a lateral umbel or two on the side of the scape. These lateral umbels consist of two to five flowers and are usually two or three inches apart. Commonly there is but one, which is one and a half to three inches below the terminal one. When there are two the lower one has fewer flowers than the upper, and this always has fewer than the terminal one. In one specimen there are seven terminal flowers and five in the lateral umbel below them.

I do not deem this a variety, but a mere form which grows intermingled with the typical form. I have observed it in several places in the Adirondack region, where it is not rare, and also near Cooperstown Junction. It seems singular that such an interesting form has not yet been noticed in any of our botanies. It was first recorded by me in the Fortieth Report, p. 73.

Juncus militaris *Bigel.*

Highland lake. July The plants are plentiful along the shore of the lake, between Myers House and Sand beach. The descriptive character, "rather contracted panicle," given in the Manual, does not apply well to these plants, for they have the panicle large and loose. It is generally about four inches long and nearly as broad. In many of the plants the stem is rather abruptly bent about midway between the insertion of the long leaf and the panicle, or at the place of the large bract-like sheathing base of an abortive upper leaf. Probably this abrupt flexure has suggested the common name "bayonet rush," which is sometimes applied to the plant, and perhaps, also, the specific name "militaris." Nevertheless no notice is taken of this very noticeable character in the description given in the Manual.

Typha angustifolia *L.*

Professor Dudley has described a variety of *Typha latifolia*, under the name *elongata*. In it both the leaves and spikes are elongated, the former being "2 to 3½ meters" long, the latter "often 30 centimeters."

A similar variety of *Typha angustifolia* is found along the shore of Cayuga lake, between the railroad bridge and the outlet. In it the fertile part of the spike is eight to ten inches long. It may be designated var. *longispicata*, though I suspect it is merely a luxuriant development of the common form.

Pontederia cordata *L.*

Specimens of this plant were collected in Highland lake in which the fibrous roots had a beautiful purple color. Var. *angustifolia* Torr. occurs here; also in Stissing pond, Dutchess county.

Potamogeton Nuttallii *Ch. & Sch.*

A form of this species was collected in the upper waters of the Oswegatchie river near Sternbergs, in which the stem branches freely, and the leaves are unusually narrow. It is here characterized as var. *ramosus*. Stem slender, branched; floating leaves with blades 1.5 to 2.5 in. long, 3 to 6 lines broad; submerged leaves 1 to 2 lines broad. The name *P. Pennsylvanicus* Cham. is applied to this species in the Manual. I have followed Dr. Morong in nomenclature.

Potamogeton amplifolius *Tuckm.*

This is one of our most common species. It occurs in all parts of the State, in still or flowing, shallow or deep, soft or hard, warm or cold water. In deep water it is destitute of floating leaves. In Thompson's lake it skirts the whole western and a part of the eastern shore in water four to six or eight feet deep, and is always destitute of floating leaves. The foliage generally has a rufous tint. It seems to avoid more shallow water. The same form occurs in Warner's lake and behaves the same way.

Potamogeton lonchites *Tuckm.*

Specimens were collected in and near the outlet of Seneca lake in which, though in flower, the floating leaves were wanting or but little different in texture size and shape from the submerged leaves.

Potamogeton heterophyllus *Schreb.*

Specimens referable to form *longipedunculatus* Morong were collected near the outlet of Seneca lake.

Potamogeton lucens *L.*

This species occurs in Oneida and Cayuga lakes. The var. *Connecticutensis* Robbins was collected in Stissing pond near Pine Plains. This is the only station recorded for it in our State.

Potamogeton filiformis *Pers.*

Cedar lake, Herkimer county. July. This is *P. marinus* of the Manual. It is scarcely separable, in some of its forms, from *P. pectinatus* in the absence of fruit, and it has probably been often confused with that species.

Potamogeton pectinatus *L.*

A form of this species is abundant in Warners lake, Albany county, in which the peduncle is whitish and 8 to 12 inches long.

In the N. Y. State Flora nine species of Potamogeton are recorded. The number of species now known to belong to the State is twenty-seven, all of which, except *P. lateralis*, are represented in the Herbarium.

The following is a list of the names of the species, varieties and forms as given in the Monograph of Dr. Morong and in the Manual:

Morong's Monograph.

Potamogeton natans *L.*
P. Oakesianus *Robbins.*
P. Nuttallii *C. & S.*
P. amplifolius *Tuckm.*
P. pulcher *Tuckm.*
P. alpinus *Balb.*
P. lonchites *Tuckm.*
  Var. Noveboracensis *Morong.*
P. heterophyllus *Schreb.*
  Form graminifolius (*Fr.*) *Morong.*
  Form longipedunculatus (*Merat*) *Morong.*
  Form maximus *Morong.*
P. angustifolius *B. & P.*

Potamogeton lucens *L.*
  Var. Connecticutensis *Robbins.*
P. prælongus *Wulf.*
P. perfoliatus *L.*
  Var. Richardsonii *Bennett.*
P. confervoides *Reichb.*
P. crispus *L.*
P. zosteræfolius *Schum.*
P. obtusifolius *M. & K.*
P. Hillii *Morong.*
P. foliosus *Raf.*
  Var. Niagarensis (*Tuckm.*) *Gray.*
P. pusillus *L.*

Potamogeton	major (*Fr.*) *Morong*.	Potamogeton	Spirillus *Tuckm.*
P.	Vaseyi *Robbins.*	P.	filiformis *Pers.*
P.	lateralis *Morong.*	P.	pectinatus *L.*
P.	diversifolius *Raf.*	P.	Robinsii *Oakes.*

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Potamogeton	natans *L.*	Potamogeton	perfoliatus *L.*
			Var. lanceolatus *Robbins.*
P.	Oakesianus *Robbins.*	P.	Tuckermani *Robbins.*
P.	Pennsylvanicus *Cham.*	P.	crispus *L.*
P.	amplifolius *Tuckm.*	P.	zosteræfolius *Schum.*
P.	pulcher *Tuckm.*	P.	obtusifolius *M. & K*
P.	rufescens *Schrad.*	P.	Hillii *Morong.*
P.	fluitans *Roth.*	P.	pauciflorus *Pursh.*
			Var. Niagarensis *Gray.*
P.	heterophyllus *Schreb.*	P.	pusillus *L.*
	Var. graminifolius (*Fr.*)	P	mucronatus *Schrad.*
		P.	Vaseyi Robbins.
		P.	lateralis *Morong.*
P.	Zizii *M. & K.*	P.	hybridus *Mx.*
P.	lucens *L.*	P.	Spirillus *Tuckm.*
	Var. Connecticutensis. *Robbins.*	P.	marinus *L.*
		P.	pectinatus *L.*
P.	prælongus *Wulf.*	P.	Robbinsii *Oakes.*

Eriophorum lineatum *B. & H.*

Low moist ground near Middle Grove. July.

Carex trisperma *Dewey.*

A form with the leaves more narrow than usual was collected on the boggy shore of Highland lake.

Carex retroflexa *Muhl.*

In the Manual, this sedge is subjoined to *C. rosea* as a variety. It differs considerably from that species in its range as well as in its appearance and characters. I do not find it at all in the northern and northeastern counties of the State, but it is not rare in some of the southern and western counties. *C. rosea* is common everywhere except perhaps in the coldest mountain regions.

Carex rosea *Schk.* var. **staminata** *n. var.*

Culms very slender but erect or nearly so 12 to 20 inches high, much surpassing the very narrow leaves; spikes commonly 4, distant, each terminated by a conspicuous staminate part subtended by 1 to 6 perigynia, or sometimes one or more wholly staminate, the lowest one either with or without an exceedingly slender setaceous bract; perigynia either horizontally spreading or conspicuously deflexed. Cooperstown Junction. June.

This plant seems to approach variety *Texensis* but it differs in its distant spikes, deflexed perigynia and conspicuous staminate flowers.

Carex æstivalis *Curt.*

This rare sedge is plentiful on the high wooded hills near East Worcester. It grows both in the woods and in open places by the roadside.

Carex retrocurva *Dew.*

This is *C. laxiculmis* Schw,.in the Manual. It has a form *serotina*, in which the new growth of the season, after the usual fruiting time, sends up short culms and produces another crop of fruit. In this case the pedicels are rather short and erect and the spikes are few flowered. Taberg and Helderberg mountains.

Carex debilis *Mx.*

A variety *interjecta* Bailey in litt. to C. L. Shear, was discovered by Mr. Shear near Alcove, Albany county, and has since been found by myself near Pierrepont Manor, Jefferson county. It fruits in June. It differs from the ordinary form in its shorter perigynia, which by being loosely arranged on the rachis often give a moniliform appearance to the fertile spikes. The staminate spike usually has 2 to 4 perigynia a short distance below its apex. Sometimes the fertile spikes are also conspicuously staminate at the apex, and occasionally one has a short branch at its base.

Var. *strictior* Bailey. A form of this variety, having culms 12 to 18 inches high and yellowish green foliage, occurs near East Worcester. June. The broad leaves overtop the culms and the spikes are noticeably erect.

Carex Œderi *Ehrh.*

This sedge was found growing with *C. flava* on the shores of Thompson's lake, Albany county. The two were so markedly different in appearance that it is very unsatisfactory to me to make the former a variety of the latter, as is done by some botanists.

Carex Emmonsii *Dew.* var. **elliptica** *Boott.*

In the Eighteenth Report on the State Cabinet of Natural History, p. 155, the characters of this sedge are published. It is described as having the spikes crowded; the perigynia rather long ($1\frac{6}{10}$–$\frac{8}{10}$ of a line long, $\frac{6}{10}$ broad), hirsute, nearly twice the length of the scale; achenium elliptical-triquetrous ($1\frac{1}{10}$ of a line long, $\frac{1}{2}$ a line broad), style deciduous at the base. New York, *Knieskern.*

The variety has a longer body to the perigynium and a longer achenium, and the pubescence is softer and longer, and the proportionate length of the perigynium to the squamæ gives a peculiar aspect to the spike. It has not been noticed by authors: *F. Boott.* Penn Yan; Rochester, *Dewey.*

This sedge has not to this day been properly recognized in the Manual.

Dr. E. C. Howe, who has made a special study of carices and to whom specimens of this plant were sent for examination, considers it a good species, and has sent the following description of it under the name

Carex Peckii *nov. sp.*

Stems 3 to 16 inches high, culm leaves 2 to 5, very short, narrow, radical leaves 3 to 10 inches long, about one line broad; staminate spike small, sometimes inconspicuous; fertile spikes 2 to 3, aggregated, the two uppermost 3 to 8-flowered, the lowest 2 to 6, bracteate; perigynia 1.5 to nearly 2 lines long, about half as wide, elliptical-triquetrous, prominently beaked, strongly hirsute, longer than the ovate acute or acutish-mucronate scarious margined scale, long and tapering at the base; scales centrally green, the sides tinged with brown or purplish-brown; achenia triquetrous-elliptical, strongly 3-ribbed, prominently stipitate, 1 line or more long.

Helderberg mountains, Albany county; Brownville, Jefferson county; Elizabethtown, Essex county. Also collected by the late Professor Dewey in Yates and Monroe counties, and elsewhere in New York by the late Dr. Knieskern.

The largest specimens were collected at Brownville, the smallest near Elizabethtown. The plants grow in thin woods or their borders or where they are partly shaded by trees. The specimens were collected in June. Doctor Howe considers the species related to *Carex deflexa* rather than to *C. Emmonsii.* Both its peculiar appearance and its distinctive spikes and fruit lead me also to think it is a valid species.

Carex Houghtonii *Torr.*

Near Elizabethtown. May. This rare species has been observed in several places by Prof. Burt and myself in Saratoga and Essex counties, but I am not aware of its occurrence elsewhere in the State It is an early flowering species, and delights in light sandy soil, through which it extends its creeping rootstocks.

Carex utriculata *Boott.*

A small form of this species is found in the Adirondack region. Its spikes are scarcely more than an inch long, being smaller even than those of variety *minor.*

Setaria viridis *Bv.*

The form of this grass noticed in the Thirty-fourth Report, p. 56, still persists about Albany and in its streets and yards. The same or a similar form is said, by Dr. Vasey in his Monograph of the Grasses of the United States and Canada, p. 38, to occur in the South. It is easily distinguished from the ordinary form of the species, and appears to be very constant in its characters. I have labeled our specimens Var. *purpurascens*, and the grass has been published and essentially characterized under this name by Prof. Dudley in his Catalogue of Cayuga plants, p. 122. Its spike like panicle is more slender than in the type, 2.5 to 3 inches long, about 6 lines broad, including the setæ, 2.5 to 3 lines exclusive of the setæ, the clusters toward the base separated and verticillate as in *S. verticillata*, the setæ tinged with purple. Its resemblance to *S. verticillata* is closer than to *S. viridis* but its setæ are barbed upwards.

Festuca ovina *L.*

The sheep's fescue is rare with us. A small patch of it was observed on the banks of the Delaware river at Narrowsburg. July. The specimens have the tall culms of variety *duriuscula*, but the panicle is contracted and the leaves involute.

Bromus purgans *L.*

This was considered a distinct species by Linnæus and stands as such in the N. Y. Flora. But modern botanists have generally connected it with *B. ciliatus* as a variety. I could wish it might be restored to its original position, for as far as my observation goes it is easily distinguished from *B. ciliatus* by its smaller, differently colored, less drooping panicle, its fewer spikelets, its more hairy flowers and its different habitat. It likes shade and most often grows in rocky woods. I have not observed it in the Adirondack region where *B. ciliatus* is quite common.

Danthonia spicata *Bv.*

The panicle in this grass is contracted after flowering. It varies in length from less than an inch to two and a half inches. Two forms occur. In one the leaves and sheaths are glabrous except a tuft of hairs at the throat of the sheaths. In the other the leaves and lower sheaths are clothed with long soft hairs. To distinguish this form I designate it Var. *villosa.* Specimens of it were collected at Brownville and Taberg.

Coprinus micaceus *Fr.* var. **granularis** *n. var.*

Pileus sprinkled with whitish granules or furfuraceous scales. Fulton chain, Hamilton county. August.

Polyporus versicolor *Fr.* var. **carneiporus** *n. var.*

Pores dull flesh-color. Ithaca. *Dudley.*

Dædalea unicolor *Fr.* var. **fumosa** *n. var.*

Pores smoky-brown. Dead birch, *Betula lutea.* Ithaca. October. *Dudley.*

Solenia anomala *Pers.* var. **orbicularis** *n. var.*

Receptacles collected in orbicular groups and seated on a conspicuous, dense, persistent, tomentose, tawny subiculum. Dead branches of appletree. Alcove. March. *Shear.*

Tubercularia carpogena *Pk.*

This name is preoccupied and I substitute for it *Tubercularia decolorans.*

Gyromitra sphærospora (*Pk.*) *Sacc.*

Ithaca. *Dudley.* This species was discovered twenty years ago. A single specimen was received from Prof. Dudley, which is the first one I have seen since the original discovery. The species is evidently rare. I am not aware that any specimens except the New York ones are in existence.

Urocystis Waldsteiniæ *Pk.*

Cooperstown Junction. June. Usually every leaf on the diseased plant is affected by the fungus. The attacked plants do not flower so far as observed. In some instances an old dead and dried leaf of the previous year showed the marks of the fungus, thus indicating that the fungus is perennial.

(E.)

LIST OF NEW YORK FUNGI REPRESENTED AT THE WORLD'S COLUMBIAN EXPOSITION AT CHICAGO, IN THE HORTICULTURAL BUILDING, SECTION S, COLUMN 33, SPACE 304.

Specimens from New York State Herbarium.

Exhibitor — Chas. H. Peck, Albany, N. Y.

Edible Fungi.

1 Amanita cæsarea *Scop.*
2 A. rubescens *Fr.*
2*a* A. " Wartless form.
3 Amanitopsis vaginata (*Bull.*) *Roz.*
3*a* A. " var. livida (*Pers.*).
3*b* A. " var. fulva (*Schæff.*)
3*c* A. " var. nivalis (*Grev.*)
4 Lepiota procera *Scop.*
5 L. naucinoides *Peck.*
6 Armillaria mellea *Vahl.*
6*a* A. " clustered specimens.
6*b* A. " var. bulbosa *Peck.*
6*c* A. " var. albida *Peck.*
6*d* A. " var. glabra *Gill.*
6*e* Abortive mushroom.
7 Tricholoma transmutans *Peck.*
8 T. imbricatum *Fr.*
9 T. personatum *Fr.*
10 Clitocybe nebularis *Batsch.*
11 C. media *Peck.*
12 C. infundibuliformis *Schæff.*
12*a* C. " Pressed specimens.
13 C. cyathiformis *Fr.*
14 C. laccata *Scop.*
14*a* C. " Pale irregular form.
14*b* C. " var. amethystina (*Bolt.*)
14*c* C. " var. pallidifolia *Peck.*
14*d* C. " var. striatula *Peck.*
15 Pleurotus ulmarius *Bull.*
15*a* P. " Pressed specimens.
16 P. ostreatus (*Jacq.*) *Fr.*
16*a* P. " Large tuft.
17 P. sapidus *Kalchb.*
18 Hygrophorus virgineus (*Wulf.*) *Fr*
19 H. pratensis (*Pers.*) *Fr.*
20 H. miniatus *Fr.*

21 Lactarius deliciosus (*L.*) *Fr.*
22 L. volemus *Fr.*
23 L. subdulcis (*Bull.*) *Fr.*
24 Russula virescens (*Schæff.*) *Fr.*
25 Cantharellus cibarius *Fr.*
26 Marasmius oreades *Fr.*
27 Cortinarius collinitus (*Pers.*) *Fr.*
28 C. violaceus (*L.*) *Fr.*
29 C. armillatus (*A. & S.*) *Fr*
29*a* C. " Pressed specimens.
30 C. cinnamomeus (*L.*) *Fr.*
30*a* C. " var. semisanguineus *Fr.*
148 Paxillus involutus (*Batsch*) *Fr.*
31 Agaricus arvensis *Schæff.*
32 A. silvicola *Vitt.*
33 A. campester *L.*
33*a* A. " Cultivated form.
34 A. placomyces *Peck.*
35 Coprinus comatus *Fr.*
36 C. atramentarius (*Bull.*) *Fr*
36*a* C. " var. silvicola *Peck.*
37 C. micaceus (*Bull.*) *Fr.*
37*a* C. " var. conicus *Peck.*
38 Boletus scaber *Fr.*
38*a* B. " var. niveus *Fr.*
39 B. subluteus *Peck.*
40 B. subtomentosus *L.*
41 Boletus affinis *Peck.*
42 B. castaneus *Bull.*
43 Polyporus sulphureus (*Bull.*) *Fr.*
43*a* P. " thicker form.
44 Hydnum repandum *L.*
45 H. rufescens *Pers.*
46 H. coralloides *Scop.*
47 Fistulina hepatica *Fr.*
48 Craterellus cornucopioides (*L.*) *Pers.*
49 Clavaria botrytes *Pers.*
50 C. flava *Schæff.*
51 C. cristata *Pers.*
51*a* C. " Large form.
51*b* C. " Dense form.
52 Lycoperdon cyathiforme *Bosc.*
53 Gyromitra esculenta (*Pers.*) *Fr.*
54 Morchella esculenta (*L.*) *Pers.*
55 M. conica *Pers.*
56 M. angusticeps *Peck.*
56*a* M. " Small form.
57 M. deliciosa *Fr.*
58 M. semilibera *DC.*
59 Helvella crispa (*Scop.*) *Fr.*
59*a* H. " Small form.
60 Mitrula vitellina (*Bres.*) *Sacc.*
60*a* M. " var. irregularis *Peck.*

Fungi Growing on and Injurious to Wood.

61 Panus stipticus (*Bull.*) *Fr.*
62 P. operculatus *B. & C.*
63 Lenzites betulina (*L.*) *Fr.*
64 L. vialis *Peck.*
65 L. sepiaria *Fr.*
65*a* L. " var. porosa *Fr.*
66 Schizophyllum commune *Fr.*
67 Polyporus elegans (*Bull.*) *Fr.*
68 P. osseus *Kalchb.*
69 P. chioneus *Fr.*
70 P. guttulatus *Peck.*
71 P. undosus *Peck.*
71*a* P. " Resupinate form.
72 P. crispellus *Peck.*
73 P. fumosus (*Pers.*) *Fr.*
74 P. adustus (*Willd.*) *Fr*,
74*a* P. " var. carpineus (*Schw.*)
75 P. Weinmanni *Fr.*
76 P. borealis (*Wallr.*) *Fr.*
77 P. pubescens (*Schum*) *Fr.*
78 Polyporus cuticularis (*Bull.*) *Fr.*
79 P. nidulans *Fr.*
80 P, gilvus *Schw.*
81 P. glomeratus *Peck.*
82 P. resinosus (*Schrad.*) *Fr.*
83 P. betulinus *Fr.*
83*a* P. " Spotted specimens.
83*b* P. " Young and old plants.
83*c* P. " Brown pubescent form.
84 P. volvatus *Peck.*
85 P. lucidus (*Leys.*) *Fr.*
86 P. pinicola *Fr.*
86*a* P. " Older plants.
86*b* P. " Pale margined specimens.
36*c* P. " Various forms.
87 P. applanatus (*Pers.*) *Wallr*
87*a* P. " Dusted by its spores.
87*b* P. " Various forms.
88 P. fomentarius (*L.*) *Fr.*

88*a* Polyporus fom. Older plants.
88*b* P. " Elongated forms.
88*c* P. " var. zonatus *Peck.*
88*d* P. " Various forms.
89 P. igniarius (*L.*) *Fr.*
89*a* P. " Old plants.
90 P. nigricans *Fr.*
90*a* P. " Old plants.
90*b* P. " var. applanatus *Peck.*
90*c* P. " Subresupinate forms.
91 P. connatus *Fr.*
91*a* P. " Resupinate form.
92 P. carneus *Nees.*
92*a* P. " var. subzonatus *Peck.*
92*b* P. " Resupinate form.
92*c* P. " Various forms.
93 P. conchatus (*Pers.*) *Fr.*
94 P. piceinus *Peck.*
94*a* P. " Resupinate form.
95 P. biformis *Klotz.*
95*a* P. " Resupinate form.
96 P. conchifer *Schw.*
97 P. aureonitens *Pat.*
98 P. hirsutus *Fr.*
98*a* P. " var. albiporus *Peck.*
98*b* P. " var. nigromarginatus (*Schw.*)
99 P. zonatus *Fr.*
100 P. versicolor *Fr.*
100*a* P. " Dark-colored forms.
100*b* P. " Pale-colored forms.
100*c* P. " var. fumosiporus *Peck.*
100*d* P. " Various forms.
101 P. pergamenus *Fr.*
101*a* P. " Effused mycelium.
101*b* P. " var. pseudopergamenus (*Thum.*)
101*c* P. " var. elongatus (*Berk.*)
101*d* P. " Old plants.
102 P. abietinus *Fr.*
102*a* P. " Form zonatus.
102*b* Polyporus abiet. var. irpiciformis *Peck.*
102*c* P. " Resupinate form.
103 Glœoporus conchoides *Mont.*
103*a* " Resupinate form.
104 Poria subacida *Peck.*
105 Trametes suaveolens (*L.*) *Fr.*
106 T. cinnabarina (*Jacq.*) *Fr.*
107 T. Trogii *Berk.*
108 T. mollis *Fr.*
108*a* T. " Resupinate form.
109 T. sepium *Berk.*
109*a* T. " From railroad ties.
110 Dædalea quercina (*L.*) *Pers.*
111 D. unicolor (*Bull.*) *Fr.*
111*a* D. " Old plants.
111*b* D. " Plane form.
111*c* D. " Complicate form.
111*d* D. " var. fumosipora *Peck.*
112 D. confragosa *Pers.*
112*a* D. " Brown specimens.
112*b* D. " var. Cookei *Peck.*
112*c* D. " var. rubescens *Peck.*
112*d* D. " var. Klotzschii *Peck.*
112*e* D. " Irregular forms.
113 Merulius tremellosus *Schrad.*
114 M. lacrimans (*Jacq.*) *Fr.*
115 Irpex cinnamomeus *Fr.*
116 Odontia lateritia *B. & C.*
117 Stereum complicatum *Fr.*
117*a* S. " var. laceratum *Peck.*
145 S. bicolor (*Pers.*) *Fr.*
145*a* S. " Old plants.
146 S. versicolor (*Sw.*) *Fr.*
147 S. sericeum (*Schw.*)
118 Chlorosplenium æruginosum (*Œd.*) *DeN.*
118*a* Wood stained by its Mycelium.
119 Wood permeated by Mycelium.
120 Bark overrun by Mycelium.

Fungi Injurious to Cultivated and Useful Plants.

121 Glœosporium lagenarium (*Pass.*) *S. & R.*
122 Plowrightia morbosa (*Schw.*) *Sacc.*
122*a* P. " on wild red cherry.
122*b* P. " on wild black cherry.
122*c* P. " on beach plum.
122*d* Plowrightia morbosa on cultivated plum.
123 Monilia fructigena *Pers.*
123*a* M. " on plums.
123*b* M. " on pears.
123*c* M. " on twigs and leaves of of apricots.

124 Entomosporium maculatum *Lev.*
124*a* E. mac. on pear leaves and fruit.
125 Plasmopara viticola (*B. & C.*) *B. & DeT.*
125*a* Plasmopara " on fruit of wild grape.
125*b* Plasmopara " on leaves of Niagara grape.
126 Phytophthora infestans (*Mont.*) *DeBy.*
127 Peronospora parasitica (*Pers.*) *Tul.*
128 Cladosporium fulvum *Cke.*
129 Cercospora Apii *Fres.*
130 C. beticola *Sacc.*
131 Puccinia Malvacearum *Mont.*
132 Ustilago Maydis (*D. C.*) *Cd.*
132*a* U. " on ears of Indian corn.
133 U. Tritici (*Pers.*) *Jensen.*
134 U. Hordei (*Pers.*) *K. & S.*
135 U. Avenæ (*Pers.*) *Jensen.*
136 Cryptospora Gœppertiana *Kuhn.*
137 Dimerosporium Collinsii (*Schw.*) *Thum.*
138 Hypoderma lineare *Peck.*

Fungi Injurious to Noxious Weeds and Animals.

139 Empusa Muscæ *Cohn.*
140 Sporendonema myophilum *Sacc.*
141 Cystopus candidus *Lev.*
142 Peronospora Linariæ *Fckl.*
143 Puccinia suaveolens (*Pers.*) *Rostr.*
143*a* P. " Later form.
144 Ustilago Cesatii *Wald.*

Recapitulation.

	Species.
Edible fungi	61
Fungi growing on and injurious to wood	63
Fungi injurious to cultivated and useful plants	18
Fungi injurious to noxious weeds and animals	6
	148

(F.)

PRELIMINARY LIST OF HYMENOMYCETOUS FUNGI INHABITING THE WOOD OR BARK OF THE TRUNKS OR BRANCHES OF OUR PRINCIPAL CONIFEROUS FOREST TREES.

Tsuga Canadensis. *Carr.*

Hemlock.

Armillaria mellea *Vahl.*
Tricholoma decorosum *Pk.*
T. multipunctum *Pk.*
Clitocybe ectypoides *Pk.*
Collybia platyphylla *Fr.*
C. abundans *Pk.*
C. rugosodisca *Pk.*
C. succosa *Pk.*
Mycena Leaiana *Berk.*
M. epipterygia *Scop.*
Omphalia lilacifolia *Pk.*
O. Campanella *Batsch.*
Pleurotus porrigens *Pers.*
P. striatulus *Fr.*
Naucoria bellula *Pk.*
N. geminella *Pk.*
Paxillus atrotomentosus *Fr.*
P. panuoides *Fr.*
Panus stypticus *Bull.*
P. lacunosus *Pk.*
Lenzites sepiaria *Fr.*
L. betulinus *Fr.*
Lentinus lepideus *Fr.*
Polyporus lucidus *Leys.*

Polyporus benzoinus *Fr.*
P. pinicola *Fr.*
P. epileucus *Fr.*
P. cæsius *Fr.*
P. undosus *Pk.*
P. crispellus *Pk.*
P. maculatus *Pk.*
P. Weinmanni *Fr.*
P. borealis *Fr.*
Polystictus abietinus *Fr.*
Poria vulgaris *Fr.*
P. subacida *Pk.*
P. Vaillantii *Fr.*
P. rhodella *Fr.*
Trametes cinnabarina *Fr.*
Trametes sepium *Berk.*
Merulius himantioides *Fr.*
M. subaurantiacus *Pk.*
Solenia villosa *Fr.*
Hydnum farinaceum *Fr.*
Mucronella calva *Fr.*
Tremellodon gelatinosum *Pers.*
Stereum sanguinolentum *A. & S.*
S. rugosum *Fr.*
S. radiatum *Pk.*
Hymenochæte tenuis *Pk.*
Corticium amorphum *Pers.*
Dacrymyces deliquescens *Duby.*
Ditiola radicata *Fr.*
Clavaria abietina *Fr.*

Picea nigra *Lk.*

Spruce.

Clitocybe sulphurea *Pk.*
Mycena purpureofusca *Pk.*
M. hiemalis *Osb.*
Omphalia Austini *Pk.*
Lenzites sepiaria *Fr.*
L. heteromorpha *Fr.*
Lentinus lepideus *Fr.*
Polyporus Schweinitzii *Fr.*
P. picipes *Fr.*
P. aurantiacus *Pk.*
P. volvatus *Pk.*
P. dualis *Pk.*
P. carneus *Fr.*
P. pinicola *Fr.*
P. borealis *Fr.*
Polystictus piceinus *Pk.*
P. versicolor *Fr.*
P. balsameus *Pk.*
P. abietinus *Fr.*
P. variiformis *Pk.*
Poria subacida *Pk.*
Poria vaporaria *Fr.*
P. vulgaris *Fr.*
P. odora *Pk.*
P. mutans *Pk.*
P. marginella *Pk.*
Trametes serpens *Fr.*
Merulius Ravenelii *B. & C.*
M. molluscus *Fr.*
Hydnum farinaceum *Fr.*
Caldesiella ferruginosa *Sacc.*
Irpex fuscoviolaceus *Fr.*
Odontia fusca *C. & E.*
Stereum rugosum *Fr.*
S. radiatum *Pk.*
S. ambiguum *Pk.*
Hymenochæte abnormis *Pk.*
Corticium sulphureum *Fr.*
C. subincarnatum *Pk.*
C. subaurantiacum *Pk.*
C. cremoricolor *B. & C.*
Hirneola auricula-Judæ *Fr.*

Abies balsamea *Mill.*

Balsam fir.

Clitocybe sulphurea *Pk.*
Pleurotus mitis *Pers.*
Lentinus strigosus *Schw.*
Polyporus pinicola *Fr.*
P. volvatus *Pk.*
Polystictus abietinus *Fr.*
Polystictus balsameus *Pk.*
Merulius aureus *Fr.*
Stereum balsameum *Pk.*
Corticum sulphureum *Fr.*
C. amorphum *Pers.*
Hirneola auricula-Judæ *Fr.*

Pinus Strobus *L.*

White pine.

Tricholoma flavescens *Pk.*
T. rutilans *Schœff.*
Collybia rubescentifolia *Pk.*
Pleurotus striatulus *Fr.*
Lenzites sepiaria *Fr.*
L. vialis *Pk.*
Lentinus lepideus *Fr.*
Paxillus atrotomentosus *Fr.*
P. panuoides *Fr.*
Boletus hemichrysus *B. & C.*
Polyporus osseus *Kalchb.*
P. pinicola *Fr.*
Poria pinea *Pk.*
Merulius lacrimans *Fr.*
Tremella pinicola *Pk.*
T. foliacea *Pers.*
Dacrymyces deliquescens *Duby.*

Pinus rigida *Mill.*

Pitch pine.

Pluteus umbrosus *Pers.*
Lenzites sepiaria *Fr.*
Polyporous circinatus *Fr.*
P. volvatus *Pk.*
P. Weinmanni *Fr.*
Polystictus abietinus *Fr.*
Poria vaporaria *Fr.*
Trametes Pini *Fr.*
Stereum sanguinolentum *Fr.*

REPORT

OF THE

STATE ENTOMOLOGIST

FOR THE YEAR 1893.

REPORT.

Office of the State Entomologist,
Albany, *August* 28, 1893.

To the Regents of the University of the State of New York:

Gentlemen.— The recent change made by the resolution of your board in the time for the presentation of the annual reports of the Scientific Staff of the State Museum, viz., that they be presented in readiness for printing by the first of July of each year, instead of the first of November as heretofore, has prevented the preparation of the usual report of the State Entomologist, containing the studies of the insects to which his attention has been given during the year.

The purpose of this change is understood to be, the printing of the reports during the summer or autumn of the year of their presentation and before the legislative printing shall engage the entire time and resources of the State Printer.

The early publication of scientific studies and investigations is unquestionably very desirable: without it, much of their interest and value is lost, or the credit due them accrues to later studies having prompt and earlier publication.

Your Entomologist, however, fears that under the new arrangement the earlier publication of his studies will not be attained. The entire occupancy of his time during the spring and early summer in investigating the many insect attacks that belong to this part of the year, and in the correspondence connected therewith, and attendant field studies, can leave barely the opportunity for making the notes which are to be worked up into proper form during the autumn and winter. A report presented in July, to be printed probably during the November following, could contain but little beyond the results of the preceding year. If it were possible so to arrange that the reports of the several members of the State Museum Scientific Staff, covering the entire year's operations, could be printed during the spring following thereafter, it would, I am confident, leave nothing further in time of publication to be desired. The present system has been found to be unsatisfactory and vexatious, as may appear from the delay attending the printing of the State Museum Reports for the years 1891 and 1892 — the reports of the Geologist, Botanist, and Entomologist contained therein being still in MS. The reports for 1891 narrowly escaped destruction in the burning of the State Printing House, in September, 1892.

Increasing Interest in the Work of the Department.

The work of my Department continues to increase in proportion to the greater interest that is being taken in it, as the result of annually increasing insect ravages, the necessity of resisting them if serious losses shall not be sustained, and a conviction that experience has given our agriculturists that it is within their power to lessen these losses very materially through a faithful use of the means that the economic Entomologist has pointed out.

Applications for aid in meeting insect attacks have been numerous, and in nearly every instance it has been possible to return information that could not fail of being of service to the inquirer. The correspondence of the office is steadily growing. Much of the information sent from it has been in communications made to leading agricultural papers, and to the local press when some new form of attack is apparently confined to a limited portion of the State. In replies to inquiries, which are often limited to the name of the depredator and remedies or protection, it has been the aim to add such details of life-history and habits, especially if not previously published, as may tend to give them permanent value and serve as additions to the steadily increasing stock of economic entomological literature.

Publications of the Entomologist.

Including a few papers printed in scientific journals, more than fifty publications have been made by the Entomologist during January–August of the present year. The usual list, giving titles, place of publication and summaries of contents, will be communicated for the next report.

Additions to the State Collection.

The aggregate of the additions to the State collection through the Entomologist from January to August inclusive, as already reported to your board, is 1775 specimens, which, with a few exceptions, have been ticketed with locality and date of collection. Of these, 1399 have been mounted and 388 have been labeled with their scientific name.

Contributions to the collection have been made, during the same time, by 52 contribntors, consisting of about 160 examples.

Collections Made in the Adirondack Mountains.

The additions made to the State collection have been mainly, as in preceding years, in the Adirondack region of the State. The collections made in Keene valley, Essex county, this season, during portions of the months of July and August, were larger than usual. Lepidoptera attracted to light were unusually abundant. Over six hundred examples, mostly belonging to the *Noctuidæ*, were taken by this means. Two species of *Plusia* — a genus containing perhaps the most beautiful of our Noctuids — *P. u-aureum* and *P. mortuorum*, which in former years have been comparatively rare in the Adirondacks, although belonging to high altitudes, were this year really common — more common, indeed, than any other species. The first *Plusia purpurigera* ever taken by me was captured on August 6th. As the Plusias have place among the rarer of our Noctuidæ, and are always regarded as desirable additions to collections, the several species taken at Keene valley this season, with the number of each, is herewith given:

Plusia (Deva) purpurigera *Walker*, 1
P. ærea *Hübner*, 1
P. æroides *Grote*, 9
P. balluca *Geyer*, 8
P. bimaculata *Stephens*, 4
Plusia precationis *Guenée*, 10
P. u-aureum *Grote*, 84
P. mortuorum *Guenée*, 58
P. simplex *Guenée*, 8

The total number of Plusias — all taken within doors — was 183, not including many worn and rejected examples appearing in August.

Comparing the above with the collections reported by Mr. W. W. Hill, in the western portion of the Adirondacks (Lewis county) during the four years, 1875–1879,* we find that nearly

*In *Seventh Report on the Survey of the Adirondack Region of New York*, 1880, p. 387.

twice as many examples of *P. u-aureum* and *P. mortuorum* were taken this year as in the four years cited — or 142 as against 82. Of species contained in the Hill List, and not seen at Keene valley this season, are the following: *Plusia Putnami* Grote, *P. thyatiroides* Guenée, *P. formosa* Grote, *P. mappa* Gr.-Rob., *P. viridisignata* Grote, *P. epigæa* Grote, and *P. ampla* Walker. These, however, are among the rarer species, and only thirteen examples are reported in the List.

The following of the *Noctuidæ* were among the most common that came to light, and of each from ten to thirty examples were obtained:

Adelphagrotis prasina (*Fabr.*)
Noctua baja *Fabr.*
Noctua Normaniana (*Grote*)
Noctua bicarnea *Guenée*
Agrotis (Feltia) subgothica *Steph.*
Agrotis (Feltia) tricosa *Lintn.*
Agrotis redimicula *Morr.*
Mamestra purpurissata *Grote*
Mamestra meditata *Grote*
Mamestra olivacea *Morrison*
Xylophasia dubitans (*Walker*)
Tricholita signata *Walker*

In contrast with the abundance of *Noctuidæ*, there was almost an entire absence of some other insects which in other seasons have been observed in large numbers. Thus, of the attractive and conspicuous family of the "hover-flies" or *Syrphidæ*, scarcely any were seen except the small form of *Sphærophoria cylindrica*, which seems almost inseparably associated with the golden-rods of August. The *Bombylidæ* were much less abundant on the damp spots in roadways than usual. Scarcely any of the "Dragon-flies," or Odonata, were seen; and indeed but few Neuroptera, except three species of *Phryganidæ*, which shared with the moths in attraction in the evening to lighted rooms. Coleoptera were not common. In a locality — a dried roadway ditch — where in 1892 hundreds of *Cicindela repanda* could be taken by simply swinging the net from side to side as one walked rapidly along, hardly any were met with.

Operations Against the Gypsy Moth in Massachusetts.

In preceding reports I have written of the accidental introduction into the State of Massachusetts, in the year 1869, of the destructive European Bombycid, "the gypsy moth," *Ocneria dispar* — of the probability of its entering New York and spreading over adjoining States — and of the efforts being made, under the direction of the Massachusetts State Board of Agriculture, for its extermination while within the limited locality of the northeastern part of the State, where it is at present confined.

This is the fourth year of active operations against this insect under annual appropriations by the State Legislature, which have now amounted in the aggregate to $275,000.

In June last an invitation was extended to me by the committee of the State Board of Agriculture to visit the infested district in company with the State Entomologists of adjoining States, for the purpose of inspecting the work of the committee, and to offer such suggestions or criticisms as it might be thought proper to make.

Every facility was afforded for thorough examination, such as witnessing the field operations of spraying, kerosening and burning rocky and waste places; banding and liming trees for preventing the ascent of the caterpillars; personal inspection of the present condition in most of the twenty towns in which the insect has occurred; the experimental work being conducted at the Insectary at Amherst, in testing the susceptibility of the larvæ to various insecticides, and the study of the life-history of the insect and its habits; the method of recording by the office staff the field observations made by the force of nearly two hundred employes; the various instruments and appliances used in the field-work, with the manner of their use, etc., etc.

The inspection was very satisfactory and gratifying and at the same time instructive, as showing what may be done in arresting insect depredations when the task would seem almost a hopeless one. I had not expected to find that such progress had been made toward the extermination of the myriads of the notorious gypsy moth. It was a surprise to me that in the brief space of three years, the fearful ravages of the insect, as described to me and as pictured in photographs, could have been reduced to such a degree of comparative harmlessness, that to the ordinary observer no indication of its presence was visible; and in a ride of an entire day though several of "the worst infested towns," including a visit to localities which had been frightfully scourged, not a single example of the larva could be found by me, although diligent search for it was made.

How a work of such magnitude — extending over two hundred square miles, with the insect so abundant that in one locality the entire side of a house was so closely covered with the caterpillars that the point of a pencil could not be thrust among them without touching them — could have been accomplished, was an enigma to me until the means by which it was done had been shown and explained to me.

The only suggestions that occurred to me to offer to the committee in response to their request, were these two: Now that the mechanical details of field-work were rapidly diminishing with the steady reduction of the insect, there was both the greater need and the opportunity of such scientific work as might serve to complete the labors of the committee and present the result in form that would render it available for future use whenever the necessity might arise for a resort to similar methods in other insect invasions hereafter. A volume or two, which should treat exhaustively of the gypsy moth and the methods employed for its extermination, might be another contribution to natural science which would rank with those which Massachusetts had already made.

It was also recommended that at this stage of the committee's work, the cultivation of the parasites of the gypsy-moth (of which about a score of native ones are already known) be entered upon and conducted with all the knowledge and skill that could be brought to bear upon it.

A plan for the artificial rearing proposed was suggested, embracing in brief these points: The entire collection of the pupæ for this year, which might amount to twenty thousand, should be preserved, placed in suitable cases, and kept, through cold storage, from giving out their parasites until caterpillars of suitable age and reared from eggs gathered for the purpose, could be inclosed with them to receive the entire parasitic oviposition. The parasitized caterpillars should be properly guarded until their pupation, when the parasites that they would disclose within the cases should have a caterpillar supply in readiness for them. This round could be repeated as long as there seemed to be the necessity for it and the parasites could be obtained.

By the above method, or by some modification of it, it would seem that an actual extermination of the insect can be effected, and possibly in no other way.

In view of what has already been accomplished, there is abundant reason for a continuance of the appropriations by the Legislature of Massachusetts until the desired extermination is secured, or until the insect shall have been reduced to entire harmlessness and in position never again to develop in injurious numbers or to invade other States. Knowing as we do, the frightful ravages of the gypsy moth in the past, and the certainty that, if left to itself, its natural multiplication would soon carry it over the entire State, it would unquestionably be a wise economy if its extermination could be attained through the expenditure of a million of dollars. It may be recalled in this connection that the wheat-midge inflicted upon the wheat crop of the State of New York in one year — 1854 — an estimated loss of fifteen millions of dollars.

The Destructive Wheat-Midge in Western New York.

This last named insect, *Diplosis tritici*, has been noticeably injurious in Western New York this present season. Attention was drawn to its operations in the wheat fields of Orleans, Genesee, Monroe and other neighboring counties during the last of June. A correspondent, from Monroe county, of the Country Gentleman, under date of August 28th, wrote as follows of it: "The wheat-midge has done much damage to the old variety of wheat — the Clawson — most commonly grown here. It is estimated that one-fourth of the crop has been destroyed by it, and farmers are alarmed about the future prospect of wheat growing in this section. The insect has approached us in about the same manner as in 1853–54; lightly at first but increasing until the entire destruction of the crop in 1856, and continued until 1860, when it began to decrease as gradually as it came, until it disappeared. The best safeguard against the midge is an early variety of grain." The writer commends an early variety of red wheat grown in Michigan, which is also very productive, yielding him forty bushels to the acre while the Clawson seldom exceeds twenty bushels.

Remarkable Abundance of Aphides or Plant-Lice.

Without entering into detail, at the present, of the insect operations of the spring and summer of 1893, brief reference will be made to some of them.

The early spring did not bring to notice, either through personal observation or that of my correspondents, the usual number of injurious insects. The earliest to claim attention, were the aphides, or plant-lice — more or less abundant every year, but in some seasons becoming very numerous and correspondingly destructive.

The opening of the apple-tree buds in early May was attended with such an unusual abundance of the apple-tree aphis, *Aphis mali* Fabr., as to excite apprehension of their effect upon the coming fruit crop. Many letters were sent to me in relation to them. The necessity of preventing their increase by spraying was urged on my correspondents, unless a heavy and continued rain should occur before they would be sheltered by the leaves — say within ten days or a fortnight after their hatching. Mr. C. C. Risley, Chairman of the Executive Committee of the Hop Growers Association, of New York, writing under date of May 9th, stated that hop growers were reporting large numbers of plant-lice on the buds and blossoms of fruit trees and on rose-bushes, recalling the conditions existing in the spring of 1886, in which year the hop crop of the State of New York was almost wholly destroyed by the hop-vine aphis. This year the fruit trees seemed even more infested than they were at that time. He especially wished to know what significance, if any, this might have with respect to hop injuries the present year.

Answer was made that the past winter had apparently been very favorable for the protection and preservation of aphis eggs, and unless the young, recently hatched or now hatching could be speedily destroyed by a heavy rain fall, which, at this stage of their existence, is so fatal to them, we would, in all probability, find the present year characterized by an abundance of aphides equal to that of 1886. It was therefore recommended that, if natural causes did not intervene to prevent this multiplication, the hop growers, on the first appearance of the insect in their yards, should proceed to kill them by proper spraying before they could produce new generations and extend over the entire yards. Directions for spraying with kerosene emulsion — perhaps the best insecticide for use against this insect — and how to make the emulsion, accompanied the letter.

In response to a request from the editor of the *American Farmer*, for information for the benefit of its readers in regard to the multiplication of plant-lice as reported from New York, the following communication was made and published in the issue of that journal for June 1, 1893:

"The remarkable abundance of these destructive little pests on the opening buds and tender leaves of fruit trees in the State of New York this spring is exciting a great deal of interest and considerable apprehension among fruit growers. The apple tree has been particularly infested, the insect occurring on it, the *Aphis mali*, being one that multiplies under favoring conditions in excessive numbers, entirely covering twigs and standing one on another, and sucking out all the sap until the parts attacked are blighted.

"From some portions of the State reports have reached me of the opening buds of apple trees being literally covered with these plant lice, or aphides as they are scientifically known. As the reports have come from eastern, central, and northern counties, it would appear as if the condition was general throughout the State. Whether it also extends into adjoining and other States is as yet unknown to me.

"To inquiries made of the probable effect of this attack on the coming fruit crops, I have replied that it was unusually severe, and apparently exceeded anything that we had experienced since the year 1886, when the superabundance of plant lice of different species inflicted serious losses, and the hop aphis almost destroyed the hop crop of the State of New York. It was therefore desirable that fruit growers should spray their trees at once with kerosene emulsion, strong soap suds, or tobacco water, and not wait until the aphides have greatly multiplied and found shelter within the curled leaves where the insecticide could not reach them. A long, cold rain following in a week or ten days the appearance of the insect, would probably be quite as beneficial as the spraying recommended, if we could judge from observations in preceding years, but, of course, this providential aid could not be counted upon.

"Since then we have had throughout the State heavy rains, continuing with more or less intermission, amounting to from two to three inches of fall. It was not a cold rain, however, and judging from a few reports since received (I have not been able to make personal observations) it failed to prove very efficient in the desired direction, for the apple aphis is said to be about as abundant as before.

"Our hop growers also are feeling considerable anxiety, for the same conditions that favor an unusual number of the apple aphis would naturally tend to the multiplication of the hop aphis, as was so markedly illustrated in 1886.

"The hop growers have therefore been advised to keep close watch for the first appearance of the hop aphis on the upper leaves of the outer rows of their hop yards. They will probably be seen there about the last of May or the first of June as full-grown, winged females, which have just flown from neighboring plum trees, where the winter had been passed in the egg and the early spring as wingless females.

"If these, the mothers and progenitors of a number of successive broods through the summer, are killed at this time by proper spraying with suitable insecticides — in the proportion that they are destroyed will subsequent injury to the crop be prevented.

"It is said that in England the hop growers do not attempt to grow a hop crop without their regular 'hop washings,' which we call spraying."

Reports of unusual abundance of aphides on fruit trees came from the following counties, indicating that they were not confined to any particular part of the State: Westchester (on apple and cherry in June), Dutchess, Schoharie (buds literally covered in June), Schenectady, Chenango (on apples and pears in May), Oneida and Onondaga in May, Madison, Oswego and Chautauqua.

Of the hop vine aphis, *Phorodon humuli*, the most severe injury seems to have been caused in the southern part of Dutchess county, where hop yards were entirely stripped, save here and there a blackened, perforated leaf of a new shoot. Nothing was done to stop the ravages of the insect; so quickly did it do its work that it was almost done before it was discovered. The crop is an entire failure (*New York State Weather Crop Bulletin*, July 8th, 1893). In Madison county the destruction of the crop was threatened in early July, but a more favorable condition was reported later. Spraying was resorted to in several of the counties — in Franklin and others — with gratifying results.

A Grasshopper Plague in Western New York.

It has been a remarkable year for grasshoppers. Their abundance in the western part of the State, where dry weather has prevailed to the extent of severe drouth, has made them a veritable plague. It is very unusual that occasion arises for complaints of injuries from them to crops in the State of New York. About the middle of July they were reported as numerous in the western portion of the State, since which time, up to the last of August, their number and their destructiveness have been on the increase. After the heavy rainfall of the 28th–29th August, amounting to over six inches in some localities, a marked diminution in number was observed. They appear to have been particularly injurious in the more western counties. Mr. J. A. McCullom, of Niagara county, writing toward the latter part of August, states that most of their crops have been destroyed entirely by the ravenous insects or so damaged as to be worthless. From Erie county it is reported: "Grashoppers have settled down upon this section of Western New York and eaten every green thing in sight. The loss will be very large. Acres on acres which a short time ago were fresh and green with ripening crops are now barren wastes of leafless stalks and branches. At first but little attention was paid to the flying and hopping pests, but as they increased in number hourly, the farmers became alarmed and steps were taken to drive them away. A strong mixture of salt and water was used, but had little effect." (*Associated Press.*) In Chautauqua county fields of oats were stripped of their grain early in August, and "garden truck" wholly destroyed, while in Cattaraugus and Allegany counties they were very numerous at the same time. In Wyoming county, after consuming the corn, they began to eat the leaves of the fruit-trees. In Genesee county, they were reported as "eating every green thing." In Orleans county "they had never been seen in such numbers before." Along the southern range of counties they were quite destructive in Steuben (much oats were cut prematurely for fodder in order to save it), Chemung, and Tioga. In Central New York they inflicted much damage in Madison county, and northwardly toward the lake shore in Oswego county, where the cabbage crop suffered severely. In the northern part of the State, as in Franklin county, they were less destructive, but pastures and meadows were reported as suffering from them.

As usual in the State of New York, a large proportion of the injuries committed this season, as above reported, is chargeable upon our two most common species of grasshoppers, viz., the red-legged locust (commonly called grasshopper), *Melanoplus femur-rubrum* (De Geer), and the lesser migratory locust (as designated by Riley), *Melanoplus atlanis* (Riley). In their destructive work, however, they were largely aided by other members of their family, which were also unusually abundant, among which may be named: *Melanoplus femoratus*, *Circotettix verruculosa*, *Camnula pellucida*, *Dissosteira Carolina*, and *Chortophaga viridifasciata*.

INSECT DEFOLIATORS OF SHADE AND FRUIT TREES.

The elm-leaf beetle, *Galerucella xanthomelæna* (Schr.) * has been very injurious in Dutchess county. During the month of July the elms were covered with the beetles and lost most of their foliage. The season has probably favored their multiplication. Prof. J. B. Smith reports that trees in New Brunswick, N. J., suffered more than ever from them, and in some cases not a leaf remained upon them by the middle of July. In many places the ground was covered with the fallen leaves as in autumn (*Entomological News*, iv, 1893, p. 229).

The tussock caterpillar of the vaporer moth, *Orgyia leucostigma* (Sm.-Abb.) proved a veritable plague in Albany during the month of July. Fruit trees in gardens were badly eaten by it, while of many of the elms and horse-chestnuts the foliage was entirely destroyed. From present appearances a number of the trees that suffered the most will die from the effect of their defoliation. The attack was somewhat local: at times, a single isolated tree in a row of elms would be attacked, and again, nearly all the trees ranging on one side of a block. The explanation of this may be, that in such instances, no care had been taken to remove the egg-clusters the preceding year from the trunks and main limbs of the trees or from beneath fence and wall copings and sills of the houses — the importance of which, as the chief protection against the ravages of this insect, has been repeatedly urged upon our citizens. The application of bands of loose cotton to the trunks of trees subject to its attack has been largely resorted to, but it should be borne in mind that this will only serve as a preventive when there are no egg-clusters or caterpillars on the tree or when the tree is not exposed to the dropping of hungry caterpillars from overhanging infested branches. To trees already infested, either by the eggs or the

* *Galeruca xanthomelæna* of former reports.

larvæ, the bands can only be detrimental, in interfering with descent from the tree for pupation and thereby inducing the spinning of the cocoons upon it.

The apple tree tent caterpillar of *Clisiocampa Americana* Harris, was observed in large numbers in Westchester county at the time of the appearance of the blossoms, May thirteenth. It was also reported as abundant in Dutchess county the latter part of May, and in Cortland county in early June. It is fortunate that the apple orchards of New York, however, so far as known to me, have not been subjected to visitations of this notorious orchard pest at all comparable to those experienced in Massachusetts — particularly in its northeastern portion — during the past few years. In riding through several of the towns surrounding Boston, in the month of June, the almost entire defoliation of orchards that arrested the attention was a sad and painful picture of destruction, as the thought arose of how easily it might have been averted. It fully justified the comparison often made of other insect devastations — "appearing as if a fire had swept over the trees." There was evidence that a considerable portion of the defoliation had been caused by the canker-worm, *Anisopteryx vernata* (Peck), but the unsightly presence of numerous large web nests in the forks of the branches bore ample testimony to the operations of the pestiferous tent caterpillar.

Regretting the necessity that compels the presentation to your board of so imperfect and brief a report as the above,

Respectfully submitted.

J. A. LINTNER.

APPENDIX.

INDEX TO REPORT FOR 1886.

[The few separates printed of the "Report of the State Entomologist to the Regents of the University of the State of New York, for the Year 1886," have been distributed as the "Third Report of the State Entomologist." (See list given with vii, viii and ix.) As it contained no index, it may aid in reference to its pages if the index herewith given be removed and transferred to it.]

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REPORT

OF THE

STATE GEOLOGIST

FOR THE YEAR 1893.

REPORT.

To the Regents of the University of the State of New York:

GENTLEMEN. — I have the honor to transmit herewith the annual report of the State Geologist and Palæontologist for the year 1893. This report embraces a statement of the work done by himself and assistants in the field and office, including the geologic map and the palæontology of the State.

The subjects of the report are arranged under the following heads:

Report on the Livonia salt shaft.
Report on the relations of the Helderberg limestones.
Report on the Geology of Albany county.
The Economic Geology of Albany county.
Report on the Geology of Ulster county.
The Economic Geology of Ulster county.
Report on the Geology of the Mohawk valley.
Report on the Geology of Essex county.
Report on the Geology of Clinton county.
The Geology of four townships in St. Lawrence and Jefferson counties.
Report on the Geology of Cattaraugus and Chautauqua counties.
Report on Field work in Chenango county.
List of publications relating to Geology and Palæontology of New York.
Platycnemic Man in New York.
Discussion of the Fenestelloid Genera.
Glossary and Explanations of Names.
Handbook of the Brachiopoda.

JAMES HALL,
State Geologist.

THE LIVONIA SALT SHAFT.

2

The Livonia Salt Shaft, its History and Geological Relations, Etc.

James Hall.

The history of the Livonia salt shaft has already been communicated in my previous reports, but it may be well to give a resumé of the facts in this place before discussing its geological position and relations.

On November 3, 1890, Mr. M. L. Townsend, vice-president of the Livonia Salt Company, wrote to the State Geologist that the company were then engaged in sinking a shaft of 12x22 feet at Livonia, Livingston county, N. Y.; that the depth of the shaft would be about 1,400 feet, and would pass through from 600 to 700 feet of shale rock and about the same thickness of lime rock. Mr. Townsend suggested that both the shale and lime rock would contain many interesting and valuable specimens which might be desirable for the geological department to obtain. He concluded his letter by offering to give aid in securing such specimens and render facilities for examinations of the rock formations should we wish to make such collections. To this very generous letter of Mr. Townsend, answer was made thanking him on behalf of the State for his interest in the subject and the consideration he had shown in giving us this notice of their work and offering the opportunity of making collections, and expressing a desire to take advantage of his liberal offer.

In answer to some inquiries addressed to Mr. Townsend, in the letter just mentioned, he stated, under date of November 10, 1890, that the shaft was then down about seventy feet and had just entered the shale rock, the depth named having been through drift material. He stated that in about two weeks from that date they would be blasting in the rock and would continue work night and day and that it would require about two years to complete the shaft.

This subject was first brought before the secretary of the Regents and afterwards before the Regents themselves at their annual meeting, recommending that some person be employed to collect information regarding the rocks, fossils, etc., which would be exhumed in the progress of the work, but as there was no money available for such purposes no action was taken. At a meeting of the Museum Committee on the 11th of February, 1891, Hon. Hamilton Harris offered the following resolution:

"To enable the State Geologist to accept the offer of the Livonia Salt Company, to allow the State without charge, to make records of the geological formations, and to select specimens of value found in the salt shaft, covering 12x22 feet, which the company is now sinking to the depth of 2,000 feet at Livonia, the sum of $2,000."

This resolution was incorporated in a bill which also provided for the completion of the palæontology and the geological map. This bill (Assembly Bill 1441) after passing the Assembly did not reach the Senate in time to receive action and therefore failed to become a law. Under these circumstances I then proposed, first to the secretary of the Regents and afterwards to the Committee on the State Museum, that the money apportioned for my use on the palæontology should be temporarily used for the employment of some person upon the ground at the Livonia shaft, and that this money should be refunded for the purpose originally intended. At a later period this proposition was accepted, and Mr. D. D. Luther, of Naples, commenced work in May, 1891. The money thus appropriated for the work upon the Livonia salt shaft was sufficient to pay for the services and contingent expenses of Mr. Luther during about six months, and at the annual meeting of the Regents in December (1891) we were in debt to Mr. Luther for a month's service, and it was proposed to abandon the undertaking, since no money had been received from the Legislature. At this juncture I again proposed that the money which had been apportioned for my use in the palæontology for the fiscal year, October 1891–1892, should be temporarily used for the purpose of continuing the work, since its abandonment at this time would be a loss of all that had been expended, and it was too important a matter to risk any chance of losing the continuity of the record which had been so far kept, both by written observations and by the collection of abundant specimens. This money, which had been allotted for palæontology, amounting to $450, was again appropriated to the continuation of the work on the shaft with the distinct understanding that the amount would be refunded at a future period for use in palæontological work.

By the law passed in 1892, chapter 170, means were provided for continuing work upon the Livonia salt shaft, and written records and collections have marked the progress of the work from the time of beginning (at the depth of 380 feet) to the depth of over 1,432 feet.

At the time Mr. Luther went upon the ground, in May, 1891, the rock had been penetrated to the depth of 380 feet, which would give a little over 300 feet in the shales of the Genesee and Hamilton groups, of which no accurate records had been kept, and our means of knowing the character of the rocks passed through in this interval could only be obtained from the material thrown out upon the dump, which will, in some measure, supply the deficiency.

The following summary will give all the necessary general information:

In re Livonia Salt Shaft.

Work begun by Mr. Luther in May, 1891.

	Feet.
Depth reported May 26, 1892	1,265
Depth reported August 13, 1892	1,432
Hamilton shales end at about	800
Marcellus shales at about	865
Corniferous limestone at	1,000
Oriskany sandstone at	1,005
Lower Helderberg and Water-lime at	1,023
The last fossil found was at	1,045
Salt was found at	1,369
A second bed of salt at	1,411
Bottom of shaft	1,432

The first 380 feet of the section, of which we have no positive record, owing to the delay in getting a man upon the ground, has been largely made up by Mr. Luther from natural outcrops of these strata in the vicinity, and it is hoped that the opportunity will be afforded of comparing this restoration with the actual section to be made up from the second shaft, which is about to be commenced, according to the requirements of the laws of the State of New York. Fossils received from the shaft are abundant and interesting, as will appear from the accompanying lists and observations, prepared by Mr. Clarke from the collections sent in by Mr. Luther, from the successive geological formations above indicated, during the progress of work in the shaft.

The present report is intended simply as an introduction to the detailed account of Mr. D. D. Luther, who has been constantly upon the ground for more than eighteen months during the past two years, and has sent to the State Museum a large amount of material collected during the progress of the work. The position and relations of the specimens in the Museum collections are indicated by a number upon each one, the number being recorded in a book kept for that purpose; and an account of their character and relations being preserved, both by notes and observations made at the time; and also by the construction of a continuous section of the strata from the time these observations began until the termination of the work at the bottom of the second bed of salt. This section and the records will be presented entire.

The Livonia salt shaft is situated about one mile and a half south from Livonia station, in Livingston county, New York, about two miles south from the outlet of Conesus lake and one mile east of its eastern shore. It is located upon the western slope of the high ground between Hemlock and Conesus lakes, being 187 feet above the former and 263 feet above the latter lake. The summit of the country between the two lakes is 1,215 feet above tide-water, and the mouth of the shaft is 133 feet lower, being 1,082 feet above tide-water. It lies near the head of a small stream flowing into the outlet of Hemlock and Honeoye lakes below Honeoye Falls. It is the most easterly salt


The AREA of the State of NEW YORK
covered by the outcrops of the
ONONDAGA SALT GROUP
NIAGARA
Lockport
Niagara Falls
Buffalo
ERIE
ORLEANS
Albion
GENESEE
Batavia
Leroy
WYOMING
Warsaw
MONROE
Rochester
LIVINGSTON
Geneseo
WAYNE
Lyons
Clyde
ONTARIO
Canandaigua
CANANDAIGUA L
YATES
Penn Yan
KEUKA L
SENECA
Waterloo
SENECA L
CAYUGA
Auburn
CAYUGA L
OWASCO L
SKANEATELES
TOMPKINS
OSWEGO
ONONDAGA
Syracuse
CORTLAND
ONEIDA L
ONEIDA
MADISON
CHENANGO
HERKIMER
FULTON
MONTGOMERY
OTSEGO
Salt Springvill.
Schoharie

shaft which has yet been accomplished. In latitude it is a little south of the line of the Greigsville and Retsof salt shafts, and is in a line almost due east from Geneseo, and is twenty-seven miles due south from Rochester. The elevation however of its position, or of the summit of the land on the east, is not so great as the general elevation of the higher portions of the country on the west, between Conesus lake and the Genesee valley.

The geological relations of the shaft show that it is mainly in the rocks of the Hamilton group, to the depth of about 800 feet,* the first excavation being within the limits of the northern extension of the lower Portage shales. Therefore, in penetrating to the bottom of the salt, the entire thickness of the Genesee and Hamilton groups has been passed through; the Marcellus shale, the Corniferous limestone, and the attenuated western extension of the Oriskany sandstone; as well as of the Lower Helderberg group and water lime, before coming to the Salt group proper.

The elevation at the opening of the shaft (1,082 feet above tide water), is higher than the Greigsville and Retsof shafts, but not so high as the mouths of several of the salt wells at Warsaw and vicinity in Wyoming county.

The salt group, as developed in central New York, consists of three members, the lower two making the greater part of the entire thickness of about one thousand feet. The lower member is a red shale or marl with little calcareous matter, and was the first deposit from this ancient sea after the close of the Niagara period. Following this come the green shales and marls, weathering to gray on the outcrop, and often gray before exposure. Following this member comes the water lime, which is of gray or drab color, and varies greatly in its development and thickness along its outcrop. The lower member of the group contains no mineral of any economic value, but in its exposure is available for brickmaking. The second member contains the gypsum and salt, the latter being the later deposit. The third member, the water lime, varies considerably in its characters in different exposures of its outcrops. It is an important member of the series, furnishing nearly all the hydraulic cement in the State of New York.

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* Eight hundred and sixty-five feet to the Corniferous limestone, of which seventy feet is to be accredited to the drift.

The geology of the locality and of the adjacent country will be better appreciated by an inspection of the small geological map accompanying this report. This map, as constructed and colored, is taken from a portion of a geological map of the western half of New York, prepared in 1888, and which corresponds very nearly to the scale of the base map now being prepared for the geological map of the State. The order of succession among the formations is easily seen, the Medina sandstone skirting Lake Ontario, lying at the base and being the lowest member of the geological series exposed in western New York. The second belt of color represents the limits of the Niagara and Clinton groups, the third belt being the salt group which is presented in a broad outcrop in the central part of the State, and is recognized as beginning in a narrow belt about the longitude of Sharon Springs,* and extending in a gradually widening area to central New York, and thence in a slightly narrowing width of outcrop to the Niagara river, and into the province of Ontario.†

The relations of the rock formations will be best understood by consulting the north and south section accompanying this report (Diagram No. 1), and also the east and west section (Diagram No. 2), which is intended to be a representation of the northern outcrop of all the formations, from the Hudson River group to the Catskill group, inclusive. This section is intended to show the gradual attenuation of some of the formations in the western extension, while several other important members of the series become greatly attenuated and finally thin out entirely in their eastern extension.

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* The Onondaga salt or Salina group, in its upper member, the water lime, extends eastward along the escarpment of Howe's Cave, the banks of the Schoharie creek and the Helderberg escarpment to within a few miles of the Hudson river; thence turning southward along the Hudson valley it extends to the southern limits of the State It is extensively quarried for hydraulic cement at Rondout and vicinity, and especially at Rosendale, in Ulster county The marly portion of the group below the water lime does not occur in the eastern extension of the formation, and the first evidence of the presence of salt on going westward is at Salt Springville, in Otsego county, a few miles north of Cherry Valley.

† Since communicating this report, and after it was placed in the hands of the State Printer, is was learned that the law for public printing does not provide for printing colored maps; therefore it has been necessary to withdraw the above described map. A diagram, No. 2, with a belt of color, indicating the width of the outcrop of the salt formation in its extension from a point east of Cherry Valley to the western limits of the State, is substituted for the colored geological map. The position of this outcrop as represented upon the diagram, when compared with the north and south section, Diagram No. 1, will show the geological relations of the salt group to the formations above and below.

No.

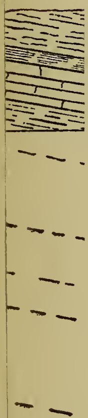


Diagram No. 1.

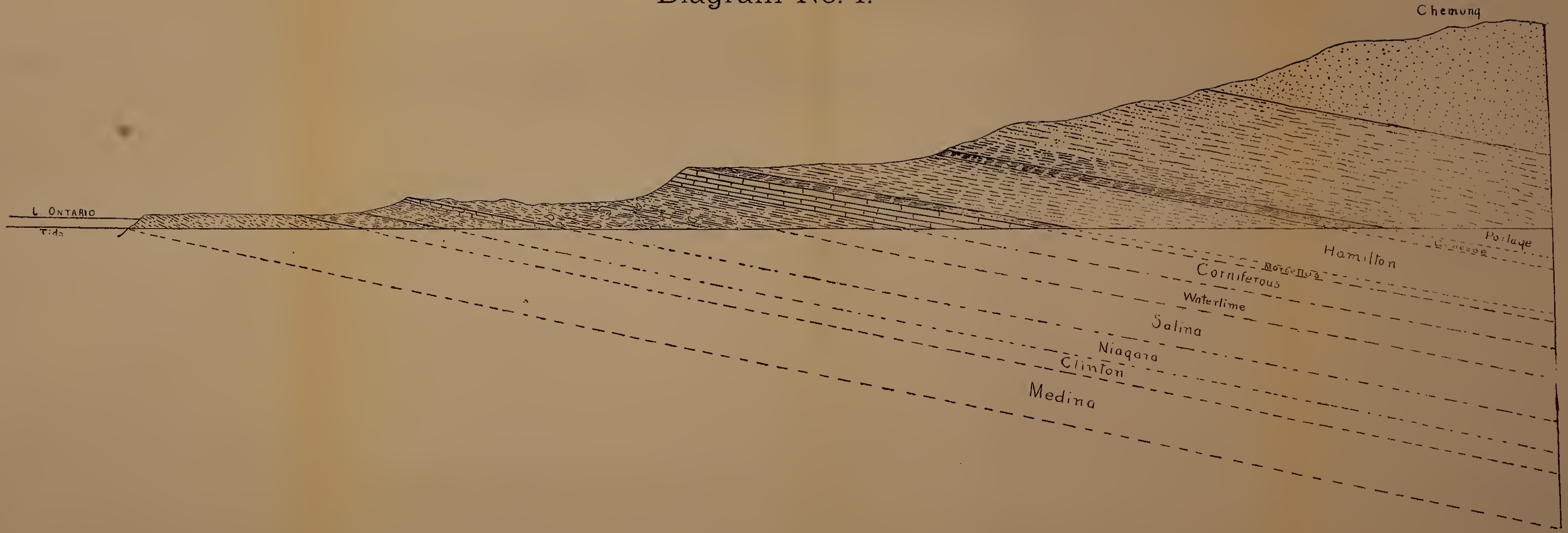
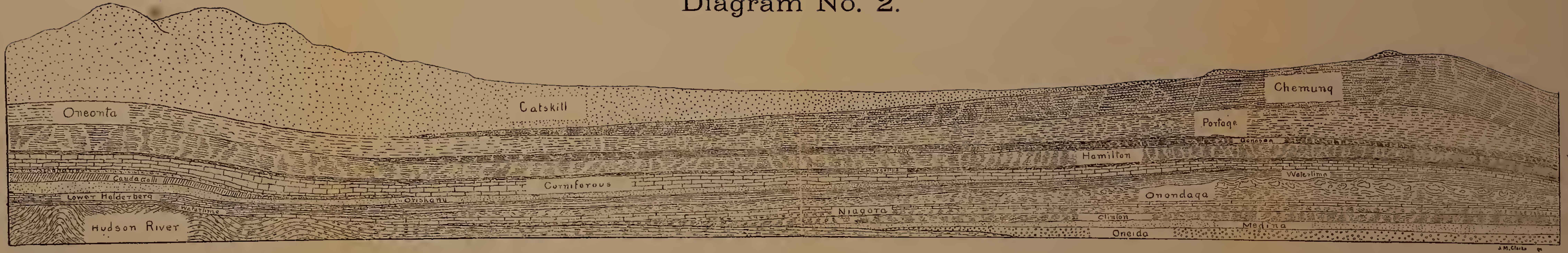

Chemung
L. ONTARIO
Portage
Hamilton
Corniferous
Waterlime
Salina
Niagara
Clinton
Medina

Diagram No. 2.

E



W

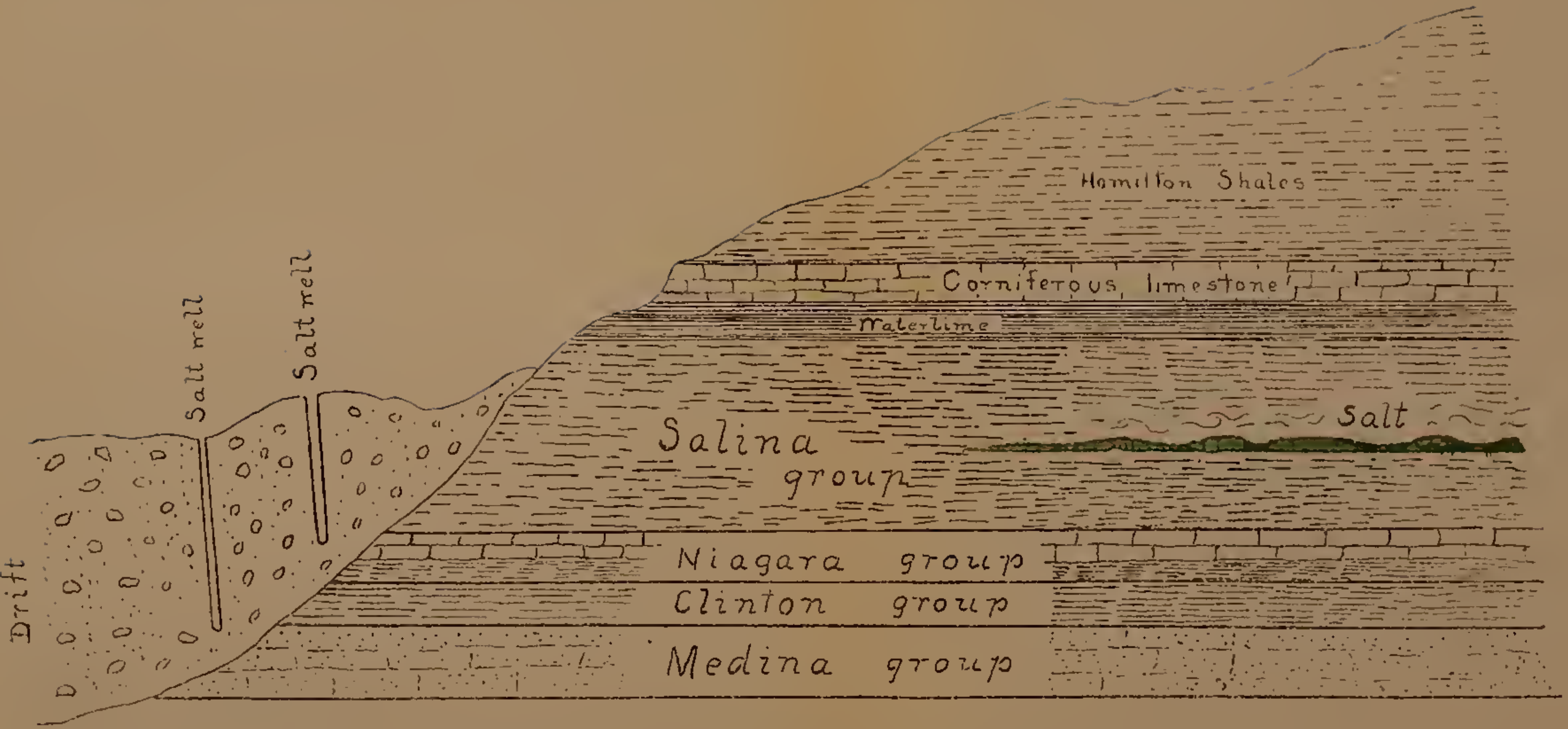
The geological position of the Livonia salt shaft is shown on both these sections, indicating and illustrating the strata which have been penetrated to reach its present depth.

The accompanying diagram (No. 3), is intended to show the geographical position of the principal salt wells and salt shafts which are now, or have been, in operation within the district embraced between Seneca lake and the western limits of Wyoming county. By comparing this diagram with the accompanying geological map, it will be easy to discover the geological position of the mouths of each of these wells or shafts; but in order to give the information more distinctly, we may indicate under each one in another diagram (No. 4), the elevation above tide water, the rock formation in which the well or shaft was commenced and the depth to which it has penetrated. These data concern the geological relations of the wells and are here given for comparison with the carefully recorded data obtained from the Livonia salt shaft. It will be observed in comparing the depths, that the farther south the point at which the well is commenced, the deeper it has to be penetrated before reaching the rock salt. This would be naturally inferred from the fact that the rocks are dipping to the southward while the surface of the country rises in the same direction at a rate greater than the dip of the strata; but the records are interesting as showing the pretty nearly uniform depth at which the rock salt is found below any of the established geological horizons, above the limits of the salt formation. To the practical man there will be little difficulty in calculating beforehand the depths to which he must penetrate the formations before reaching salt, by comparing the depth of the well or shaft on the north or south of him and adding about forty feet per mile for the dip of the rocks to the southward, and further adding the rise, or subtracting the amount of fall in the country surface in the direction from the established point to the place of his new working. With this simple knowledge and the precautions named, there need be no miscalculation as to the depth of the salt below the surface at any point within the area indicated, and which has been lately designated as the Salt Field of Western New York.

It has been only within a comparatively few years that the resources of our great salt formation have been fully appreciated. It has long been known, and the idea was advocated more than fifty years ago, that the brines which have been used for the last century in the manufacture of salt at Syracuse had their origin in the marls lying to the southward, which, in the geological nomenclature of the State, have been termed the Onondaga salt group or the Salina formation. It was long ago shown by geologists that such brines could only come from the solution and leaching of rock salt, which it was naturally presumed had been inclosed in the marls furnishing these brines; that a portion of the original ocean having become land-locked, evaporation had gone on more rapidly than the influx of sea water had been able to overcome, and that following the deposition of the sedimentary material the salt had been precipitated to the bottom essentially after the manner in which it goes on in the open air salt vats at the present time.

The practical community, however, were comparatively slow in taking advantage of this geological knowledge. The first experiments in boring wells were not successful, because they were made too near the outcrop of the formation, and therefore penetrated only that portion from which the salt had already been removed by infiltration of water from above. The accompanying diagram (No. 5) will show the relation of the salt formation to the overlying and underlying rocks. The deep accumulation of drift material on the north of the outcrop has served as a reservoir for the brines which have accumulated from the leaching of the marls and the consequent removal of the solid salt from the exposed portions of the rock; and not only the actually exposed portions in the outcrops, but beyond this so far as the water percolating through the fissures of the limestones above could reach the salt. It is only after passing the outcrop of the Hamilton group, which offers an impervious covering to the formations below, that any rock salt could be expected to exist. The salt wells of Syracuse and Salina have penetrated this gravelly drift to a depth of more than four hundred feet without reaching its lower limit. Until recently the wells sunk in this drift have supplied the brines from which all the salt of Syracuse and Salina was manufactured.

Within a comparatively few years there have been more than forty salt wells drilled, and most of them in operation, within


Hamilton Shales
Corniferous limestone
Waterlime
Salt well
Salt well
Salina group
Salt
Drift
Niagara group
Clinton group
Medina group

the territory between Seneca lake and the western limits of Wyoming county. Within the same territory there are four salt shafts completed and others in progress. Still further to the east of these, and beginning at different horizons, are several productive salt wells which are not noted in this report. The geographical position of the wells and shafts of the western district is represented on the diagram.

The work on the Livonia salt shaft has enabled us to obtain a most complete and satisfactory collection of material from the Genesee slate and thence through the Hamilton group and all the inferior strata, ending at the base of the salt group. This section will serve to give an accurate record of the thickness of each member of the series, with its variations in character, and will also serve to correct any imperfect observations which have been made upon the exposed outcrops of these several formations.

In addition to the record of the strata occurring in the Livonia shaft, Mr. Luther has supplemented his work by observations upon the formations above the Hamilton group in their best exposures, and we shall have a more complete illustration of the strata composing the Portage group in some of its phases than we have before possessed.

In the ordinary course of geological observations, our knowledge is almost wholly derived from the natural exposures along the edges or outcrops of the successive formations, whether in the main line of outcrop or in the ravines or channels of streams cutting across these outcrops. In the firmer rocks, as limestone or sandstone, the exposed layers of these rocks are often but little changed by the action of the weather, but in all shaly formations decomposition and disintegration have taken place to a greater or less degree. Under these circumstances of exposure and disintegration the contained fossils are usually much weathered and decomposed, and while the Corals and Brachiopoda may be fairly well preserved, the other classes, as Cephalopoda and Lamellibranchiata, are usually in a very unsatisfactory condition of preservation. On this account, especially, the collections of fossils from the Livonia salt shaft will be unusually valuable and interesting for the study of all the forms of ancient life from the shales of the Hamilton group and the limestones below. Not only have we obtained the fossils in a better state of preservation than heretofore, but many new species have been discovered in the material freshly excavated from the shaft at its different depths. In addition to this, we have not only better specimens and many new forms, but we are able to determine in a much more satisfactory manner the facts relating to the recurrence of similar faunas at different depths in the strata; a fact fully recognized in the description of the Hamilton group in its exposures in western New York. But in the natural exposures it was not always possible to determine accurately the exact limit of any two of these beds owing to the decomposition and disintegration of the exposed surfaces; while excavation was laborious and expensive. It was therefore only in a general way that these recurrences were noticed and recorded.

Prof. Clarke, assistant palæontologist, has made careful examinations of the extensive collections of material which have been brought into the Museum, noting the succession and recurrence of the faunas from the commencement of our work upon the shaft to the lowest horizon at which fossils have been found. The record is of great interest and importance, and such an one as could never have been obtained from the study of the outcrops of the successive formations.

Prof. I. P. Bishop, in the fifth annual report of the State Geologist, 1886, has given a very interesting history of the discovery of rock salt in the State of New York, with a complete record of the wells and of the manufacture of salt from the same, up to that date. Report of the State Geologist for 1885, pp. 12–47.

EXPLANATION OF MAP.

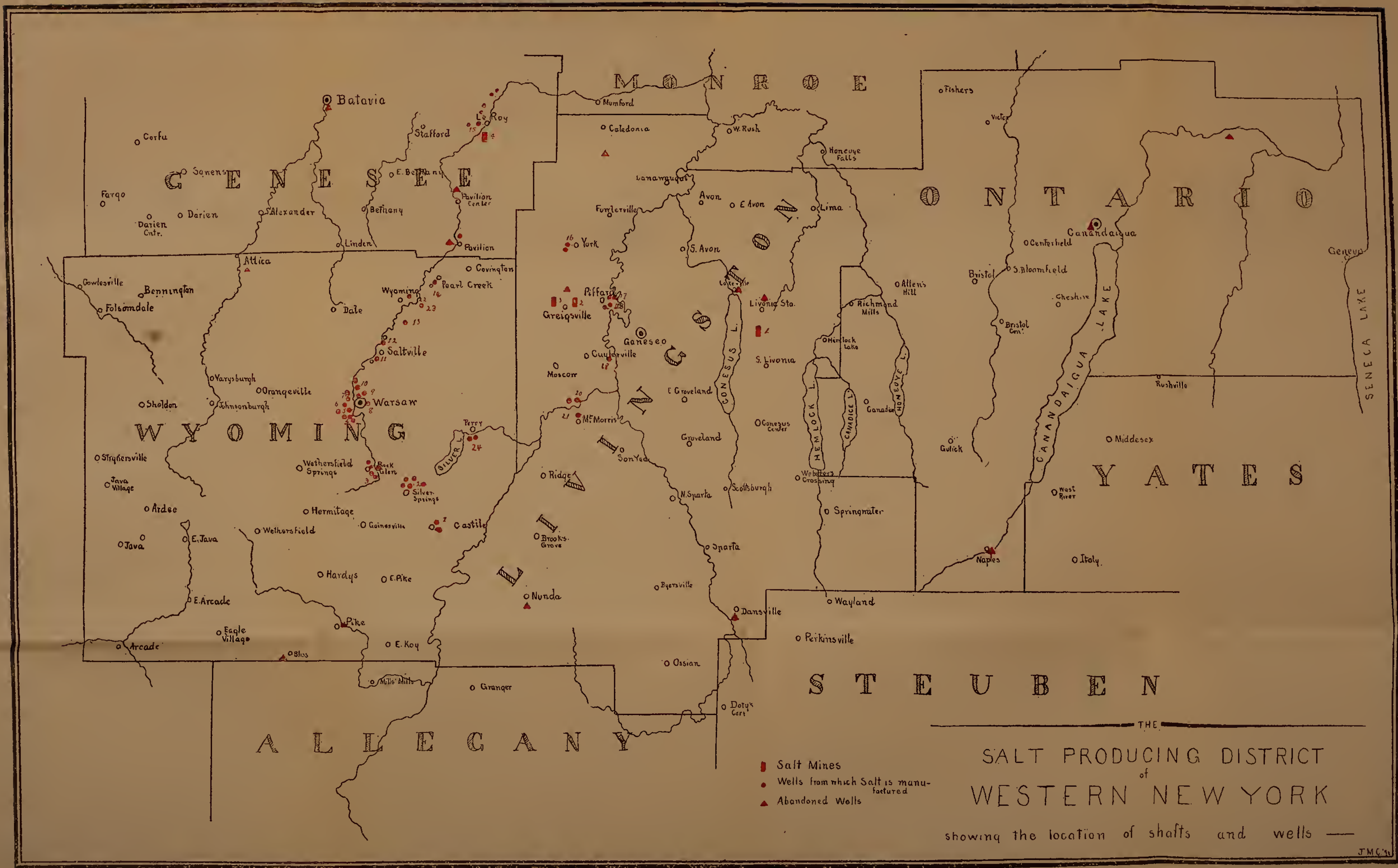
SALT MINES.

1. Livonia Salt and Mining Co.
2. Retsof Salt and Mining Co.
3. Greigsville Salt and Mining Co.
4. Lehigh Salt and Mining Co.

SALT WELLS.

1. Castile Salt Co.
2. Duncan Salt Co.
3. Kerr Salt Co.
4. Bradley Salt Co.
5. Empire Salt Co.
6. Guinlock and Humphrey, No. 1.
7. Hawley Salt Co.
8. Guinlock and Humphrey, No. 2.
9. Warsaw Salt Co.
10. Atlantic Salt Co.
11. Miller Salt Co.
12. Crystal Salt Co.
13. Humphrey and Hawley.
14. Pearl Creek Salt Co.
15. LeRoy Salt Co.
16. York Salt Co.
17. Livingston Salt Co.
18. Genesee Salt Co.
19. Phœnix Salt Co.
20. Lackawanna Salt Co.
21. Royal Salt Co.
22. Globe Salt Co.
23. Moulton well.
24. Perry Salt Co.

Diagram No. 3.



MONROE
GENESEE
WYOMING
LIVINGSTON
ONTARIO
YATES
STEUBEN
ALLEGANY
Batavia
Corfu
Le Roy
Stafford
Darien
Alexander
Bethany
Pavilion
Attica
Linden
Covington
Pearl Creek
Wyoming
Dale
Saltville
Warsaw
Orangeville
Varysburgh
Johnsonburgh
Sheldon
Bennington
Folsomdale
Perry
Silver L.
Castile
Silver Springs
Rock Glen
Wethersfield Springs
Hermitage
Gainesville
Wethersfield
Java
E. Java
Ardee
Java Village
E. Arcade
Arcade
Eagle Village
Pike
E. Koy
Hardys
E. Pike
Granger
Mumford
Caledonia
W. Rush
Honeoye Falls
Avon
E. Avon
Lima
S. Avon
York
Piffard
Greigsville
Geneseo
Cuylerville
Moscow
Mt. Morris
Sonyea
Ridge
Brooks Grove
Nunda
Lakeville
Livonia Sta.
S. Livonia
Conesus L.
Hemlock L.
Canadice L.
Honeoye L.
E. Groveland
Groveland
Conesus Center
Richmond Mills
Hemlock Lake
Canadice
Webster's Crossing
N. Sparta
Scottsburgh
Springwater
Sparta
Dansville
Wayland
Perkinsville
Ossian
Fishers
Victor
Canandaigua
Centerfield
Bristol
S. Bloomfield
Cheshire
Bristol Cen.
Allen's Hill
Canandaigua Lake
Seneca Lake
Geneva
Rushville
Middlesex
Gulick
West River
Naples
Italy
Salt Mines
Wells from which Salt is manufactured
Abandoned Wells
THE
SALT PRODUCING DISTRICT
of
WESTERN NEW YORK
showing the location of shafts and wells

Diagram No. 4.


Leroy
Pavilion Salt Co.
Pearl Creek 1st
Pearl Creek 2nd
Globe Salt Co.
Crystal Salt Co.
Miller Salt Co.
Warsaw Salt Co.
Gouinlock & Humphrey No 1.
G. & H. No 2.
Hanley Salt Co.
Empire Salt Co
Kerr Salt Co
Duncan Salt Co
Castile Salt Co
Caledonia
York Salt Co.
Greigsville
Genesee Salt Co
Livingston Salt Co
Phoenix Salt Co.
Royal Salt Co.
Lackawanna Salt Co.
Nunda
Dansville
Tide
Junction well
Lehigh Shaft
Livonia Shaft
Retsof Shaft
Tide

REPORT

ON THE

Geology of the Livonia Salt Shaft.

By D. D. Luther.

REPORT.

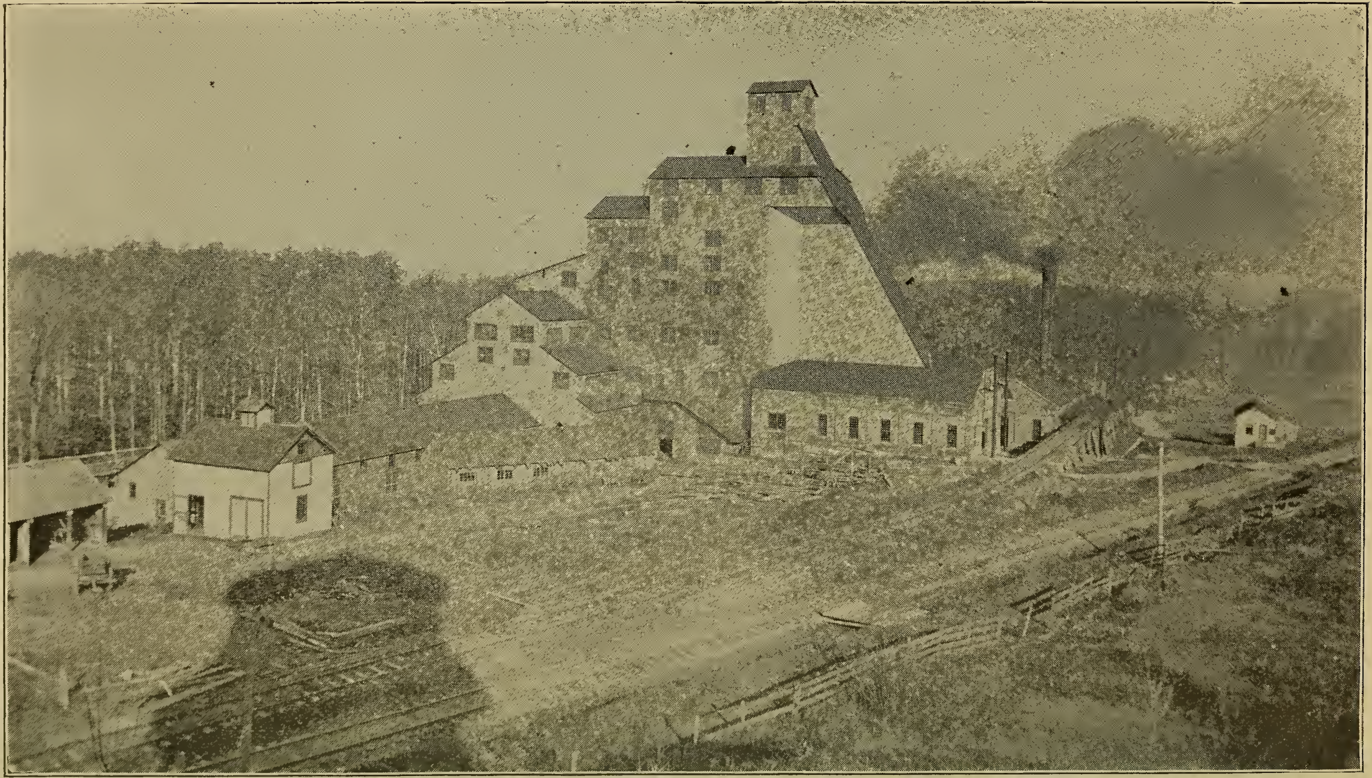
Dr. James Hall, *State Geologist:*

Dear Sir.— I herewith present my report on the rock section in the Livonia Salt Shaft, with some observations on the comparative thickness of the formations passed through there, and at other shafts and wells, and on the general geology of the Western New York Salt Field.

Respectfully yours,

D. DANA LUTHER.

PLATE 1.



VIEW OF THE LIVONIA SALT AND MINING COMPANY'S PLANT. LOOKING NORTH.

The Livonia Salt Shaft.

On the 12th day of May, 1891, in accordance with instructions received from you in person at Livonia on the ninth day of the same month, I went to the Livonia Salt Shaft to make a record of the different strata of rock passed through in sinking the shaft to and through the salt beds, and to collect representative specimens from each stratum, as well as such fossils as might be obtained from the *debris.*

From the aforesaid date to the 13th day of August, 1892, when the two beds of salt had been penetrated and the shaft had reached the depth of 1,432 feet, at which point the sinking was ended, I was present nearly every working day, having never been absent two working days in succession, and carefully examined the rock hoisted out from each layer passed through, also making frequent visits to the bottom of the shaft whenever it was necessary in order to obtain a correct record or accurate measurêment.

There were collected, packed and forwarded to your address, State Hall, Albany, N. Y., one hundred and ninety-one boxes and two barrels of fossils and other specimens showing the character of the strata.

These specimens are plainly marked with figures, which indicate their place in the strata, so far as it was possible to ascertain the precise depth from which they came. The specimens which were collected to show the lithological character are all thus marked. Such of the fossils as are not marked were collected and forwarded on account of their being individually of some value and interest. Several boxes of good specimens were collected from the large amount of material of the Genesee group and the upper part of the Hamilton group, which had been brought out previous to my arrival, and which was in a very good condition and conveniently situated for examination and working over for fossils.

The lithological record has been carefully made, and the figures given are as accurate as it was possible to obtain.

The accompanying diagram of the rock section in the Livonia shaft, from the depth of 380 feet from the surface to the bottom, where the depth is 1,432 feet, was prepared from notes made daily and shows the character of each stratum passed through. It should be borne in mind that the observations and record were made when the material was fresh, and the descriptions are intended to apply to the rock while in that condition, very little allowance having been made for the effects of exposure.

By your direction I visited several times the Greigsville Salt Mining Company's shaft at North Greigsville, in the town of York, Livingston county, N. Y., and the Lehigh Salt Mining Company's shaft, two and one-half miles south of Le Roy, Genesee county, N. Y., for the purpose of obtaining such information in regard to the rock section and the beds of rock salt at those localities as I might be able to secure, for purposes of comparison with the section in the Livonia shaft.

At both of these shafts the *debris* was well situated for examination, and the salt beds were seen and examined by descending into the mines after drifting had been begun.

I also examined the *debris* from the Retsof shaft No. 2 in the town of York, Livingston county, N. Y., and the outcropping of rock along the stream which flows by it.

I have also visited different parts of Yates, Ontario, Livingston, Genesee and Wyoming counties to examine the outcroppings of strata, and to collect data regarding the surface geology of the Western New York salt field and the geological horizon of the mouths of the salt wells, and also to note as far as possible any changes in the thickness or character of the groups or formations represented in the Livonia section.

In the prosecution of the work assigned to me, I received only the most courteous treatment from all of the officers and employes of the Livonia Salt and Mining Company with whom I have come in contact.

Mr. D. Hyman, the general manager of the company, and Mr. E. W. Johnson, superintendent, gave me unrestricted privileges, and have done everything in their power to assist me to make the record complete and accurate.

I am also under obligations to Mr. P. R. George, former superintendent, to Mr. R. H. Strickland, the present superintendent, and to Mr. J. C. Reed, for much kindness.

The existence of beds of mineral salt among the rock strata of Western New York was first discovered in a test well put down by the Vacuum Oil Co., of Rochester, N. Y., with a hope of obtaining oil or gas at the mouth of a ravine that opens into the Oatka valley, about one mile south of the village of Wyoming, Wyoming county. In the spring of 1878, at the depth of 1,270 feet in this well, a bed of rock salt, which proved to be seventy feet thick, was found.

After a year or two of hesitation, capitalists began to sink wells everywhere in the Oatka valley from LeRoy southward, and everywhere the salt stratum was found, and the erection of blocks for the production of salt by evaporation followed rapidly.

In 1881, Mr. Carl Cocher was instrumental in having a well drilled near the village of South Greigsville, in the town of York, Livingston county at a point about ten miles almost directly east of the pioneer well in the Oatka valley. It is one-half mile west of the Retsof Salt mine, and the mouth of the well is about 200 feet higher than the Genesee river.

This well is the one in which rock salt was first found in the Genesee valley. In 1883 the wells of the Livingston Salt Co. were drilled at Piffard, two miles east of the Cocher well, and the first plant for producing salt by evaporation in the Genesee valley salt district was put in operation.

In September, 1884, a company, now known as the Retsof Salt Mining Co., began the sinking of a shaft eighteen feet long and twelve feet wide, in which the salt beds were reached in September of the following year at the depth of 996 feet. The salt was found to be excellent in quality and inexhaustible in quantity. An immense building, similar to those in use in the coal mining regions, was immediately built, machinery put in, and the first salt mine in the State of New York put into operation.

This mine is situated on the eastern side of the ridge of land that separates the Genesee valley from the Oatka (formerly Allen's) creek or Warsaw valley, and is about three miles west of the Genesee river, which finds its course on the east side of the valley, and ten miles west of the Livonia shaft. The mouth of Retsof shaft is 158 feet higher than the river.

In 1884, a company was formed at Lakeville, in the town of Livonia, and a well was put down near Conesus lake, about seven miles east of the Genesee Salt Co.'s works at Piffard. Salt was reached at the depth of 1,002 feet. The bed was thirty-one feet thick and very clear.

This well is the first one in which rock salt was found east of the Genesee valley proper.

This development of the salt field was watched with great interest by a New York lawyer, Mr. Martin L. Townsend, who had his summer home at South Livonia. He made many excursions into the salt district, and, having scientific tastes, made a study of the salt beds and the rocks overlying them.

As a result of his investigations he formed the opinion that the salt beds became clearer toward the east, and that the western slope of the ridge which separates Conesus lake from the Hemlock lake valley was a favorable location for a salt mine.

Mr. Townsend had the courage of his convictions, and, in 1885, he selected a spot in a little ravine near the tracks of the Lake Erie and Western railroad, one-half mile north of Livonia Station, and about two miles a little south of east from the Lakeville wells, and contracted with Mr. Thomas Percy to put down a test well.

This well proved to be located in an ancient drift-filled channel in the rocks, once, perhaps, a part of the bed of a pre-glacial Conesus lake, and was a very expensive one — 340 feet of gravel, quicksand and clay were encountered before bed rock was reached.* At the depth of 1,189 feet, a bed of very clear salt thirty-two and one-half feet thick was reached.

No effort was made to reach the lower bed of salt, as the quality and quantity in the upper one entirely satisfied Mr. Townsend's expectations. The great thickness of the drift deposits, however, made the locality an unavailable one for mining purposes and no use has been made of the well.

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*The surface of Conesus lake is 819 feet A. T. The Lakeville wells are 824 feet A. T. with fifty-four feet of drift; the first rock there is 779 feet A. T. The mouth of Townsend's well is 1,008 feet A. T, with 340 feet of drift, and the first bed rock is 668 feet A. T. The bottom of this old channel is therefore at least 151 feet lower than the surface of the lake, and 102 feet lower than the first rock in the Lakeville wells. The present outlet of the lake is a quarter of a mile west of the Lakeville wells.

But Mr. Townsend was not to be discouraged. Selecting a site two miles south of his first well, on land owned by Mr. J. C. Reed, he had another well drilled in 1888, which penetrated both beds of salt and was sunk 109 feet into the soft shales which lie beneath them. A very careful record of the strata passed through was made by Mr. George Townsend, who kept samples of the comminuted rock every five feet.

In June, 1889, the organization of the Livonia Salt and Mining Company was completed, with a capital of $1,500,000, and the following officers: Milo M. Belding, president; Martin L. Townsend, vice-president; Milo M. Belding, Jr., secretary; William B. Putney, treasurer.

Land and mining rights were immediately purchased, and a site chosen for the present shaft about 1,000 feet south of the test well and twenty-seven feet higher.

The work of sinking the shaft was begun September 15, 1890.

The Livonia salt shaft is situated about twenty-seven miles nearly due south from Rochester, and one and one-half miles south of the village of Livonia Station, Livingston county, N. Y., and close by the side of the tracks of the Rochester division of the New York, Lake Erie and Western Railroad. It is on the western slope of the ridge which separates the valley of Conesus lake from that of Hemlock lake, and whose summit on an east and west line through the shaft is 133 feet higher than the mouth of the shaft and 1,215 feet above the level of the sea.

The mouth of the shaft is 263 feet higher than the surface of Conesus lake, 187 feet higher than Hemlock lake and 1,082 feet above the level of the sea.

Toward the north and west around the shaft, the ground falls rapidly away for a short distance to the border of a nearly level tract of several acres of swampy land, which is twenty-eight to thirty feet lower than the mouth of the shaft. The *debris* from the shaft has been used to fill up to a convenient level a part of this depression, and to make a bed for railroad tracks across it.

When first brought out the rocks were covered by a thin coating of mud, by which the fossils were obscured, and frequently entirely hidden. Except when an opportune rain storm rendered valuable assistance, it was necessary to use the hammer or scrubbing brush to bring them to view.

No record of matters connected with the sinking of the shaft was kept until my arrival, but from various sources I learned that ground was broken on the 15th day of September, 1890. From that date to the 13th day of August, 1892, the work of sinking was carried on with slight cessations day and night, Sundays excepted.

The size of the shaft before the lining of timbers and plank was put in was twenty-four feet long by fourteen feet wide. The average daily rate of sinking was 2.7 feet, about 1,000 cubic feet of rock, weighing nearly eighty tons, being hoisted out for each working day.

The process employed in sinking the shaft in the rock may be briefly described as follows:

Machine drills, driven by compressed air, which was supplied by a compressor situated in the engine house, 125 feet from the shaft, were used to drill two rows of holes across the shaft, three or four in each row, about one-third of the distance from each end. These holes were not drilled perpendicularly, but at such an angle that at the bottom the two rows would nearly meet. The holes were two and one-half inches in diameter at the top, one and one-half inches at the bottom and nine feet deep. Into these holes eight to ten sticks of dynamite, eight inches long, one and one-half inches in diameter and weighing one-half pound each, were inserted. One or more of these sticks contained a fulminating cap or exploder, to which a small wire was attached. After the dynamite had been placed in position, the holes were filled to the top with wet sand and finely pulverized rock rammed in. Then the fine wires of the exploders were attached to a larger wire connected with an electrical battery on the surface, or at least several hundred feet above, in the timbers. When the workmen had been hoisted out and everything breakable removed to the surface, the dynamite was exploded by electricity, and the V shaped mass of rock between the rows of holes was lifted out and broken into fragments.

While the broken rock in the "sink" was in process of removal, rows of holes, similar to those described, but more nearly perpendicular, were drilled and loaded in the "benches," as the mass of rock left at each end of the shaft was called, and after the sink had been cleaned out were "fired" as before. Then the last rows of holes were drilled perpendicularly in the corners and the ends blasted out.

After the blasts the workmen returned to the bottom and the "dirt" was loaded into an iron bucket capable of holding 1,500 to 2,000 pounds of rock, attached to a steel wire cable one and one-quarter inches in diameter, and the sixty horse-power hoisting engine brought it to the surface, where it was thrown into small cars, on narrow gauge tracks, which were extended or moved laterally as required, and carried to the edge of the fill and dumped from the side or end of the car down the declivity, usually fifteen to twenty feet high, the bottom and slope of which afforded good opportunity for the examination of the rock and the collection of the fossils.

In describing the successive geological formations traversed by the Livonia shaft I have compared each one with its development as observed by me in the western salt field, believing that this will be the most effective method of presenting the subject.

The first rock formation in the Livonia salt shaft is the lower shales of the Portage group.

Besides the Livonia shaft, eighteen wells, or groups of wells, which have penetrated to the salt beds at the different localities west of Seneca lake, have shales of the Portage group as the first bed rock. This group has for, or very close to, its base a bed of very black bituminous fissile shale, known as the Lower Black Band, in which fossils are very rare. Only a few plant remains, and fish plates and teeth are found. This black shale resists the action of running water better than the clayey shales above and below it, and in the shade and moisture of the ravines it is generally well exposed. Its peculiar jointed structure and blackness make its identification as a member of this group easy. It is very persistent in character and thickness and is well exposed in many places.

Overlying the black band, in Yates county, and at Naples, Ontario county, there are nearly 100 feet of fine bluish or olive shales, not quite firm enough for flagging, though flags occur in these beds more and more abundantly to the eastward, the character of the beds changing to soft clayey shale with thin sandstones. In the lower part of this bed fossils are of rare occurrence, though sometimes a thin concretionary layer may be found to contain many good specimens.

Next above are fifteen to twenty feet of soft clayey olive shales in which the impressions and casts of fossils are very abundant. Overlying these shales are about six feet of hard bluish, non-fossiliferous sandstones, then soft clay shales with recurring sandy layers for 100 feet or more to the Second Black Band.

In the ravines north of the village of Naples, on both sides of the valley, there occurs a concretionary calcareous layer, of pinkish color, three to four inches thick, a few feet above the thick sandstone just mentioned. It is exposed near the highway on the hill between Middlesex and Potter Centre, and also at Belknap's gully, two miles north of Branchport, in Yates county, where it is a layer of clear, hard limestone of a light blue color and is eight to ten inches thick. It contains many fine fossils wherever exposed, but appears to be richer in Parrish Gully, two miles northeast of Naples, than elsewhere. Along Honeoye and Conesus lakes, and at many places between them, there occurs a layer of concretions containing many fossils, which appears to be in the same horizon as the thin limestone.

Flat concretions, which in rare instances contain fossils, are abundant, sometimes constituting layers between the sandstones and the second black band.

The second black band is, at Branchport and Naples, rather more than 200 feet above the lower black band, and in Parrish Gully it is twenty feet six inches thick. It is of precisely the same character and appearance as the lower black band, and they both resemble so closely the black shales in the lower part of the Genesee group that it is only by examination of the adjacent strata that the observer can determine the horizon of either.

Toward the west these two black bands continue across the salt fields, becoming, if possible, more densely black and bituminous, and the upper one increasing to nearly 100 feet in thickness near the southwest corner of Genesee county. The shales between them, however, become very much softer and lighter colored and are not more than 100 feet thick. Flat concretions occur and fossils are less abundant.

For fifty to sixty feet above the upper black band the rock is principally soft shale, with a few thin sandstones and many concretions, in which casts and impressions of fossils are common.

Above these soft shales the character of the rock changes somewhat, the shales becoming harder, and flags and thin sandstones make up a large proportion of the strata for about 250 feet, in which Portage fossils may at rare intervals be detected.

Bituminous black shale occurs at intervals, in layers usually three to six inches thick.

The upper part of the Portage group consists of beds of sandstones from a few inches to five feet thick with shale between.

At the third falls in the Grimes Gully, at Naples, in a thin layer of dark soft shale several species of Portage fossils have been found, and in one of the several directly overlying layers of sandstone near the brink of the falls there are many impressions and casts of *Liorhynchus quadricostatus*, *Atrypa aspera* and *Ambocœlia umbonata* var. *gregaria*, and in other exposures but a few feet above this horizon Chemung fossils are abundant.

From the bottom of the lower black band to the sandstone where these fossils occur is a distance of 599 feet, which is the thickness of the Portage group in the Naples valley. The transition shales between the lower black band and the typical Genesee below are not included in this measurement.

At Rock Glen, in the Oatka valley, the Portage rocks are a little more than 800 feet thick, as shown in an accompanying diagram.

Favorable exposures of the strata of the Portage epoch may be seen at Belknap's gully and at Italy hollow, and the southern part of Middlesex valley in Yates county.

At Naples, in Ontario county, the sections in Snyder's, Parrish's and the Grimes gullies together include the whole of the formation, and there are many other ravines in the vicinity where good outcrops occur.

The Briggs gully and other ravines about the head of Honeoye lake are in Portage rocks, also the upper part of "Mill gull" near the foot of the lake. The gorge of Whetstone brook, between

Honeoye and the Hemlock valleys, exposes the second black band at the falls and nearly all of the soft shales below, which are here unusually rich in fossils, as are the numerous concretions.

The upper part of the ravine at Gullburgh, now Glenville, near the foot of Hemlock lake, is in Portage shale, the lower black band being exposed a short distance above the lower mill. In the town of Livonia, Shurtleff's gully, in the eastern part, shows an interesting exposure, and Lindsley brook, Hartson's gully and French's gully, in the western part of the town, on the eastern shores of Conesus lake, with Van Valkenberg's and others on the western shores, and Maple Beach, McMillan's and the Conesus gullies, near the head of the lake, together make a section which includes all the Portage strata. In the Dansville valley, all the rocks exposed, except those in the upper part of the hills in the south part of the valley, belong to the Portage.

The exposures of the lower beds along Cashaqua creek and the entire formation in the vicinity of Portage falls, on the Genesee river, are well known, as the latter suggested the name of the group and the former the name for its lowest division.

Except the first 100 feet, the ravine near the Lackawanna salt well, two miles northwest of Mt. Morris, on the western side of the Genesee valley, is in Portage rocks, and a fine section is here exposed. In the Oatka district the ravines on both sides of the valley about Wyoming show very fine exposures of the lower or Cashaqua shales, while those near Warsaw, particularly that of Fall Brook, show middle or "Gardeau" shales and flags to perfection, and the sandstones at the top of the formation are laid bare in the quarries of the Warsaw Stone Company, at Rock Glen, six miles south of Warsaw.

At Attica, the lower black band is exposed in the bed of the stream under the Main street bridge, and below the railroad along the Tannery brook north of the village. By ascending the south branch of this stream, a good exposure of the olive shale will be found one-quarter of a mile above the railroad.

A long deep ravine which has its mouth near the station at Griswold's, on the Lake Erie and Western railroad, shows a Portage section from the Genesee upward to include the upper black band which here is nearly 100 feet thick.

At the depth of 119 feet below the surface in the Livonia shaft the top of the Genesee group was reached. This group is 161 feet thick at this point and may be divided into the upper Genesee, the Styliola band and the lower Genesee.

The upper Genesee beds are bluish shales, quite dark except when exposed to sunshine, which gives them a much lighter color. Thin layers of bituminous black shale occur every few feet. Concretionary layers and layers of separate concretions, generally not very persistent, though some of them continue for a long distance, may be seen whenever these shales are exposed. Single spherical concretions of all sizes and flattened septaria ("turtle stones") are common. Fossils are quite abundant in the blue shales and the concretions. The black layers rarely contain other than fish and plant remains.

In the vicinity of Canandaigua lake the Genesee division includes a bed of olive and bluish soft shales about twenty feet thick, which lies immediately below the lower black band of the Portage group and contains both Portage and Genesee fossils. *Lunulicardium fragile* is, however, the most abundant form. These "transition shales" either thin out or change character in the Genesee valley and westward and are not seen.

The *Styliola band* occupies a position near the middle of the Genesee shales and extends from Middlesex, in Yates county, to Darien, in Genesee county, and probably further in both directions. It is a band of thin limestones and calcareous shales that are easily recognized after a slight examination and are so peculiar and persistent in character and so frequently exposed as to constitute a valuable landmark in the geology of the salt fields. As exposed along the shores of Canandaigua lake, this band consists of several layers of dark gray to black or bluish limestone two to four inches thick, which occur at irregular intervals through fifteen to eighteen feet of black shale. One or more of these thin limestones presents a nodular or concretionary appearance, and with the manner in which the hard and apparently sandy shale is bent over the irregular surface forms a noticeable feature at every exposure of this horizon.

Both the limestones and the adjacent calcareous shales are almost entirely composed of the acicular shells of the small pteropod *Styliola fissurella*, which J. M. Clarke, in Bulletin 16, U. S.

Geological Survey, says "are so small that they measure no more than 1½ to 2^{mm}, and so abundant that I have estimated from good specimens of the limestone at least 40,000 individuals to a cubic inch of the rock."

Plant remains are also very abundant, also *Lunulicardium fragilis* and several species of goniatites and orthoceratites, which are frequently silicified and attract attention from being so white in the dark rock. Sections of the stems of the beautiful crinoid *Melocrinus Clarkii*, Williams, are seen at nearly every exposure, and more rarely sections of a smaller one, probably a variety of *M. Clarkii.*

A full description of this exceedingly interesting band may be found in Bulletin 16, U. S. Geological Survey, by J. M. Clarke.

Toward the west the intercalated shales thin out and the limestone layers are consolidated into two or three much thicker ones. At Darien the band shows only as a compact layer of concretions, with a few inches of the calcareous shale overlying it.

Good exposures of the Styliola band may be seen in the lowest rock uncovered in the Foster gully, Middlesex valley, Yates county, and along the east side of Canandaigua lake from Genundawah Point north one and one half miles. In the Seneca Point gully, on the west side of the lake, it forms the crest of the falls, and is finely exposed. It may be seen at Bristol Centre, Ontario county, near the mouth of the ravine east of the village, and also in the smaller ravine on the west side of the valley.

It is the lowest rock exposed in "Mill Gull," east of Honeoye, where the principal layer is seen to excellent advantage, as it makes a floor averaging ten to twelve feet wide and several rods long, with the characteristic features well developed, and showing many fossils, some of them silicified. It is also exposed in one or two small ravines further north. In the ravines on the east side of Hemlock Lake valley, opposite and a little north of the village of Hemlock Lake, and in the Reed gully, the band is well exposed.

In 1893 the city of Rochester drove a tunnel from Hemlock lake to a point opposite this village — about 6,000 feet — for the purpose of conveying the water of the lake to the city.

Shafts about twelve feet square and fifty to eighty feet deep were sunk 1,000 feet apart.

Shafts Nos. 3, 4 and 5 penetrate the Styliola band, and the limestones were also encountered in the tunnel, which has an inclination of 1 : 4,000, for a distance of several hundred feet.

The only exposure of this horizon in the Conesus Lake valley is in the ravine back of Eagle Point, where it makes a low fall in the stream.

The bottom of the lowest layer is forty-nine feet above the lake.

In the Genesee valley the main layer forms the brink of the falls at Fall Brook, near Geneseo, where it measures fourteen inches in thickness and is very compact. Blocks of it, some of them ten to twelve feet across, have fallen down and are seen in large numbers. It also forms the brink of the fall near Moscow, on the west branch of Beard's creek, where it was quarried by the D. L. & W. R. R. Co., to be used in building culverts; and the fall in the ravine one mile south of South Greigsville.

It is also exposed on Fall Brook, south of Geneseo on the road leading from Geneseo to Mt. Morris, and in several ravines between Moscow and Greigsville, and it is said to be the foundation for the dam across the Genesee river at Mt. Morris.*

It is well developed and exposed in a ravine one and one-half miles southwest of the village of Pavilion, west of the old mill, where it forms the brink of a fall eighteen feet high. This is the only exposure of this horizon observed in the Oatka valley, the amount of drift being larger and the hills not steep.

At Griswold's, the first station west of Attica on the Erie railroad, in the bed of Murder creek, just above the station, it has the nodular layer more strongly developed, about eight inches thick with four inches of shaly limestone overlying it, making in all about twelve inches.

In the bed of the creek one and one-half miles west of Darien Centre, a short distance below the Erie track, it appears as a four inch layer of nodular limestone, separated by one foot of black shale from a compact layer of spherical concretions below.

This exposure, the most westerly one examined, is long and flat, a very difficult one from which to obtain correct measure-

*Mr. C. Cocher of Greigsville is authority for this statement.

ments, but the entire thickness of the Genesee division is not far from thirty-five feet, the Styliola layer twelve feet from the base and about sixty-five feet above the Encrinal limestone, which is well exposed at the falls, half a mile below.

Below the Styliola band the shale is darker, and, as the depth increases, more bituminous and fissile. A concretionary layer, about fifteen feet from the top of the lower shales, is very persistent, as is one about the same distance from the bottom of the group.

The last layer, as exposed between Richmond Mills and Hemlock lake, in a rock cutting made in laying pipes for the Rochester water works, is a compact, impure limestone six inches thick, and contains many specimens of a small coral. Between this and the top of the Hamilton the shale is very black and highly bituminous.

The total thickness of the Genesee group at Canandaigua lake is about 225 feet, at the Livonia shaft 161 feet, in the Genesee valley 125 to 150 feet, in the Oatka valley about 100 feet and in the vicinity of Darien not more than 40 to 50 feet.

The *Tully limestone* is an important and easily recognized landmark in the geology of Central New York, westward from the southwesterly part of Madison county and the north central part of Chenango county, where, according to Prof. S. G. Williams, the most easterly exposures show a thickness of fifteen or sixteen feet. It attains its greatest thickness, twenty-eight to thirty feet, in the vicinity of Skaneateles lake, and thins out toward the west, being from twelve to eighteen and one-half feet thick on Cayuga lake, fourteen feet thick along the east shore of Seneca lake from Ovid to Lodi, ten and one-half to sixteen and one-half feet thick along the outlet of Keuka lake, and seven feet, with possibly something lacking, at Bellona, in the northeast corner of Yates county.

The report on the Geological Survey of the Fourth District mentions two exposures in Ontario county, one at Bethel (now Gorham), and one four miles northwest of that place in the bed of a small stream, where it was but three feet thick.

The limestone was formerly exposed in the bed of Flint creek, in the village of Gorham, a short distance north of the flouring mill, but a dam built some way below the exposure sets the water back over it to a considerable depth, and the rock is now so covered by mud that it cannot be seen except on the rare occasions when the water is drawn off.

About twenty years ago several large blocks were quarried out and hauled on to the west bank of the creek, immediately south of the railroad bridge, where they were left and may now be seen. The more exposed parts crumbled into little angular blocks, as is frequently the case with the Tully limestone under such circumstances.

It does not appear in the banks of the stream, nor do either the Hamilton shales below or the Genesee shales above. The nearest rock exposure is in a small ravine about one-fourth of a mile southeast from the village, which shows forty to fifty feet of black Genesee shales. The lowest bedrock seen is perhaps twenty-five feet above the Tully limestone.

Without doubt the most western outcrop of this limestone is the one about five and one-half miles west, and but a few rods north of that at Gorham, and two and three-quarters miles north of the boundary line between Ontario and Yates counties, at the crossing of the road leading from Canandaigua to Rushville, known as the "lake shore road," near a small stream which empties into Canandaigua lake at Gage's Landing. It is distant not more than a mile from the lake, but the nearest exposure of that horizon (that is, of the over-, and underlying shales) on the lake shore is fully three miles away, in a southwesterly direction.

At this place ten to twelve feet of Genesee shales are exposed immediately above the limestone, and below it the Hamilton shales have been worn away, making a fall about twelve feet high, and forming a small amphitheater into which many large blocks of the limestone have fallen.

The ravine begun here continues nearly to the lake, presenting many fine exposures of the upper Hamilton beds. The limestone at this place measures thirty one inches in thickness, and is divided by a thin, shaly seam into two layers, the lower twenty-eight and the upper three inches thick. There is no noticeable difference in character in the two layers.

In the shaly seam and lower part of the thick layer, where it is somewhat shaly, fossils are quite common, *Rhynchonella* *venustula*, and *Phacops rana* being abundant, but fossils are rare in the rest of the rock, which is very dark when freshly broken, with a slightly bluish shade, and so fine, hard and glistening as to resemble flint. When long exposed it becomes light drab in color. The usual tendency to crumble into small angular blocks from weathering does not appear here, the fallen masses remaining in large blocks having the full thickness of the stratum. In the less compact shaly part at the bottom of the lower and thicker layer there occurs considerable iron pyrites in the form of nodules and shapes resembling the peculiar casts of small twigs that are so abundant in the lenticular patches of pyrites which are found separating the Hamilton shales from the Genesee at nearly every exposure of this horizon from Canandaigua lake to the western part of Genesee county and perhaps beyond.

The overlying shale is densely black, highly bituminous and very fissile, with lines of jointing one to two feet apart crossing another set at nearly right angles. No fossils were observed except a few plants. This layer maintains the same character wherever exposed from Canandaigua lake westward across the salt fields. The contrast between it and the shales below becoming more pronounced in that direction for reasons given below.

About fifteen feet of the shale immediately beneath the limestone is quite dark bluish gray, fine and soft, fissile to only a moderate degree and not at all bituminous. It contains considerable pyrites in nodules. Fossils are somewhat rare in the upper part of this bed, but are abundant in the middle and lower part. The fauna is distinctively Hamilton, though the number of species is not large. This bed may be traced toward the west, becoming gradually thinner. It is about four feet thick at Moscow, and practically disappears in the vicinity of Darien, where the light colored blue gray "Moscow shale," with its abundant fossils and concretionary layers, may be seen in contact with the black Genesee shale.

The next westward exposures of the Tully horizon are in the ravines and rock bluffs along the shores of Canandaigua lake, where for several miles the Genesee shales may be seen resting, apparently, directly upon the Hamilton, the contrast in color and character of the shales making the line of contact very distinct.

At no exposure on the east side of Canandaigua lake, nor from there to the western limit of the salt field, can any limestone, either compact or shaly, be found between the Hamilton and Genesee groups.

Occasionally, however, a thin, non-continuous layer of iron pyrites, covered with rust and with the exposed edges crumbling into fine particles, may be seen in precisely the place of the Tully limestone, and these lenticular patches of pyrites have been found to occur at every exposure of this horizon in the salt district.

They are not nodular, but rather thin sheets, compact and hard, with upper and lower surfaces comparatively smooth. They appear to rarely exceed three inches in thickness, and fifteen feet in diameter. They do not form a continuous layer, but are generally in close proximity with one another. When newly broken the edges are bright yellow, but on exposure become rusty and easily escape notice in a rock wall.

The material of which the pyrites layer is composed is very refractory, boiling acid having very little effect on it, though, in a few instances, it has been found in a crumbling condition from weathering.

One fragment, 10 x 8 x 2½ inches, found in the drift in the excavation south of the Livonia shaft, was quite soft and easily broken.

This horizon is exposed on the east side of Canandaigua lake from near Fisher's cabin, south a mile or more, and on the west side of the lake from Black point, about the same distance from the shore, and north in the ravines.

Near the top of the falls in Victoria glen the pyrites layer is three inches or more thick. It is exposed in the west bank of Hemlock outlet, near Richmond Mills, and in "Jaycox run," near Geneseo, Livingston county.

At Fall Brook, near Geneseo, it occurs about twenty-eight feet from the bottom of the falls, two inches thick; also in the top of the ravine near the village of Moscow, in the bank of the north branch of Beard's creek, and in all three of the larger ravines near the Delaware, Lackawanna and Western railroad, between Moscow and South Greigsville.

About thirty-five rods west of the Greigsville salt shaft it was exposed in a shallow excavation made in connection with the water supply, and was about four inches thick and twenty feet higher than the mouth of that shaft.

The horizon is covered with drift in the Oatka valley, the next westward exposure observed being at Griswold's, a station on the Erie railroad about fifteen miles west of the Oatka river, where a patch one and one-quarter inches thick is exposed.

The top of the Hamilton group was reached at the depth of 280 feet in the Livonia shaft. The shales immediately beneath the pyrites layer are quite dark, though differing greatly from the black shales above.

The color is lighter as the depth increases, and at 286 feet the soft, light-colored blue-gray calcareous "Moscow shale" was reached. This bed is thirty-five feet thick, and here, as everywhere in Western New York, it is exceedingly rich in fossils and contains much iron pyrites. Concretions are numerous and usually contain fossils in an excellent state of preservation.

A persistent concretionary layer of impure limestone about twelve feet below the top of the Hamilton group, exposed along Little Beard's creek, near Moscow, Livingston county, has sometimes been identified as the Tully limestone. This is a mistake. A careful examination of the overlying shales will show great numbers of characteristic Hamilton fossils, and in many places the non-persistent pyrites layers in the horizon of the Tully limestone. These Moscow shales are finely exposed along the shores of Canandaigua lake and in the ravines at Tichenor's point, Menteth's point, Foster's point and Gage's landing; also at Richmond Mills, in the western part of Ontario county. In Livingston county, Fall Brook ravine, near Geneseo, and Little Beard's creek, on the west side of the Genesee valley, are famous exposures of this horizon, and for ten miles north of the village of Moscow, along the Delaware, Lackawanna and Western railroad, good outcrops occur in the ravines and creek beds.

It is slightly exposed in the vicinity of Pavilion, in the Oatka valley, but the drift is too deep and the valley too shallow to allow good exposures.

Along the bed of the stream which is crossed by the Lake Erie and Western railroad at Griswold's there is a good natural section through the upper Hamilton shales and also along Eleven Mile creek, two miles west of Darien Centre, Genesee county.

From 321 to 333 feet below the surface in the Livonia salt shaft the rock is much less fossiliferous, darker and harder.

From 333 to 353 feet the rock was soft, bluish-gray shale, with some dark layers. The bed contains very little pyrites and concretions are rare.

The presence of many fine specimens of the lamellibranchs *Grammysia bisulcata*, *Orthonota undulata*, *Glyptodesma erectum* and entire individuals of *Homolonotus DeKayi* and other trilobites makes this bed exceedingly interesting.

From 353 to 380 feet, the depth at which the measurements and records were begun, the rock passed through was bluish, medium soft shale of much the same character as the "Moscow shales," though fossils are much less abundant and concretions are rare. At the crossing of a small stream formerly known as "Jaycox run," by the Avon road, two and one-half miles north of Geneseo, this bed is much richer in fossils than at the shaft

From the depth of 386 to 440 feet the rock taken out of the shaft was richly fossiliferous and several thin layers of limestone with shales separating them were penetrated.

These limestones are exposed in Menteth's and Tichenor's gullies, on Canandaigua lake, and at the high falls in the ravine two and one-half miles north of Geneseo. They contain fragments of crinoid columns and plates, and the lower one bears so close a resemblance to the limestone of the encrinal band that it is not always easy to identify them unless the adjacent strata are accessible for examination.

From 440 to 547 feet the soft bluish shale encountered in sinking the shaft continued with slight changes. Fossils were generally not so abundant as above, though some horizons afforded good specimens.

The *encrinal limestone* was reached at 560 feet from the collar of the shaft, and 280 feet from the top of the Hamilton group.

The hard, calcareous shales which lie immediately above an below the limestone, and with it constitute the "encrinal band," were filled with fossils. Corals were more abundant than at the exposure of this horizon near the mouth of Tichenor's glen, Canandaigua lake.

The exposures of the encrinal band in the Genesee valley were not examined by me in a ravine, but on Mr. C. J. Hill's farm, in the town of Pavilion, near Linwood, on the Delaware, Lackawanna and Western railroad. The limestones and shales are well exposed, and one and one-half miles west of East Bethany, on the same railroad, there is a rock cut sixty to eighty rods long in this horizon, where the disintegrating shale has left thousands of beautiful corals and other fossils lying on the surface of the ground.

The bed of soft shale below the encrinal band, known as the Ludlowville shales, was 233 feet thick at Livonia. The principal part of it is light bluish-gray in color, and thin layers of dark brown, slightly bituminous shale are intercalated at irregular intervals. Joints are numerous. Concretions are rare. It is generally quite barren of fossils, though a few horizons afford good specimens. It is exposed along the Conesus outlet near Avon, and in the banks of the Oatka river between Le Roy and the Delaware, Lackawanna and Western Junction.

The total thickness of the strata belonging to the Hamilton group passed through in sinking the Livonia salt shaft was 517 feet.

The Greigsville shaft was begun in the Moscow shales about twenty feet below the top of the Hamilton and sunk through 431 feet of that group. The Retsof shaft was begun about 110 feet below the top of the Hamilton group and reached the Marcellus shales at the depth of 347 feet, showing the Hamilton group to be 457 feet thick at that point.

The mouth of the salt well at Pavilion is, as nearly as could be ascertained without the use of a level, in the horizon of the top of the Hamilton. The Corniferous limestone was reached at the depth of 415 feet, according to the record. Allowing sixty feet for the Marcellus, would leave 365 feet as the thickness of the Hamilton group at the Pavilion well. Prof. Bishop's record of the well at Perry, about ten miles nearly due south of Pavilion, shows at least 477 feet of Hamilton rocks, an increase of eleven feet to the mile in that direction.

When not covered by drift the shales and limestones of the Hamilton group are exposed over a belt of country about ten miles wide, extending from east to west across the salt district.

Besides the Retsof and Greigsville shafts in the Genesee valley, the well at York, those of the Genesee Salt Company and the Livingston Salt Company at Piffard, those of the Phœnix Salt Company near Cuylerville and the Lakeville wells are opened in this belt.

In the Oatka valley the more southerly wells of the Le Roy Salt Company, the Lehigh shaft, the Junction well and the Pavilion well are also located within its limits.

No very great change in the character of the rock was observed at the depth of 797 feet in the Livonia shaft, but the shale was considerably darker and *Orbiculoidea minuta* and *Liorhynchus limitaris* suddenly appeared in great abundance, showing that the Marcellus group was reached. It is sixty-nine feet thick at Livonia. The records make it fifty-six feet thick at the Retsof shaft and sixty-one feet at the Lehigh.

The thinning out appears to be in the black shales which lie between the impure limestone at 853–854 feet and the top of the Corniferous, for at the Lehigh shaft this limestone rests directly upon the Corniferous.

The black shales and the upper (Stafford) limestone are well exposed at Littleville, near Avon, and in the bed of the Oatka creek below Main street bridge in the village of Le Roy.

Several salt wells put down by the Le Roy Salt Company and the well in Caledonia have Marcellus shales for their first rock.

The Corniferous or upper Helderberg limestones were 135 feet thick at Livonia. From the records of the other shafts and salt wells, it would appear that the thickness of the rocks generally regarded as belonging to this group is ten to fifteen feet greater in the Genesee and Oatka valleys.

In all the measurements, except at the Livonia shaft, the Onondaga limestone, distinguished mainly by the absence of chert and the abundance of corals, is included.

This Onondaga limestone was two and one-half feet thick in the shaft. At the Oatka falls below Le Roy it is ten to twelve feet thick.

The change from the soft black Marcellus shale to the hard, blue Corniferous limestone is very noticeable to the driller, and gives him opportunity for accurately determining the depth in his well to the top of the formation.

It is more difficult to ascertain the precise point at which the drill reaches the bottom of the Corniferous, the Oriskany sandstone being of too slight a thickness to attract attention, and the next rock below differs but slightly in texture.

The change in color from bluish gray to pinkish gray is the principal indication of the change in the rock, and may not, in all cases, be noticed immediately. The difference in the figures in the records is probably due more to this cause than to variation in the thickness of the strata.

In the upper part of the Corniferous beds shaly partings from a fraction of an inch to four inches thick occur at irregular intervals, and separate the strata into layers from a few inches to several feet in thickness.

At the depth of 888 feet in the shaft and twenty-two feet below the top of the Corniferous limestone, interstratified between thick layers of hard, cherty limestone, there occurs a very peculiar soft layer about four inches thick that differs widely from the usual shaly partings in that formation, in regard to the nature and origin of which some difference of opinion has been expressed by the few experts to whom specimens have been submitted.

It is glistening, brownish gray in color, with an appearance strongly suggestive of a mica schist or decomposing volcanic tufa. It is rather shaly and crumbles quickly when exposed.

There is very little doubt that it is a deposit of thin, minute hexagonal crystals flakes of sulphate of lime, the darker particles perhaps colored by iron.

No fossils were observed in this layer, but an irregular layer of soft, shaly limestone about an inch thick, which separates it from the hard overlying limestone stratum, contains many specimens common to the adjacent strata.

The layer appeared also in the Greigsville shaft and the Lehigh shaft, maintaining its thickness and presenting no apparent difference in character.

At Le Roy, Lime Rock and other localities very large quantities of Corniferous limestone are quarried from the upper beds for building stone and to be burned into quicklime. The large amount of chert in the lower beds makes them unsuitable for those purposes. The Onondaga limestone is quarried in many places.

No wells in which rock salt has been found are located on outcrops of the Corniferous limestone, nor the rocks below it, in the Western New York salt fields.

At 1,00! feet from the surface the bluish-gray Onondaga limestone was found to overlie a stratum of coarse, conglomerate rock composed of rounded boulders and pebbles of dark brown hydraulic limestone imbedded in a dark sandstone, which is quite green in some parts of the upper portion of the stratum, but in the lower portion becomes gray. The water lime pebbles also become much lighter colored.

The line of separation between this stratum and the overlying Onondaga limestone is very distinct, but on the lower side the change is less abrupt and the line of separation from the chocolate colored hydraulic limestone beneath is very uneven.

The average thickness of the conglomerate in the shaft was about five feet; at the Lehigh shaft, and at the Retsof shaft the stratum was found, preserving the same general character but reduced in thickness to about four inches.

At the Greigsville shaft there was only sufficient thickness to mark the horizon.

At Phelps, in Ontario county, it is exposed in the bed of Flint creek, where it is about two and one-half feet thick.

No fossils were observed in the water lime pebbles, but the cementing sand rock contained a few specimens.

The species determined appear to indicate that this layer may be the equivalent of both the Schoharie grit and the Oriskany sandstone.

The magnesian limestones, some thin layers of which are water lime, and hard shales between the Oriskany sandstone and the "Gypsum Beds," are 112 feet thick in the Livonia shaft, sixty-five feet in the Retsof shaft and sixty four feet at the Lehigh shaft. In the diagrams of the shaft sections, these rocks are all designated as belonging to the lower Helderberg group, though with some doubt as to the lower limit.

The fine grained, dark reddish, brown oily limestone at 1,010 to 1,024 feet, contains several characteristic species of fossils belonging to that group.

At about 1,045 feet, the rock was a dark chocolate-brown, sandy, impure limestone. In it were found a very few specimens of coral, a *Favosites* with small cells, and a cyathophylloid, in which the structure was nearly destroyed.

In a few thin layers of water limestones at about 1,105 to 1,110 feet, *Leperditia alta* was quite abundant.

At the Retsof shaft, on the surface of fragments of magnesian limestones found on the dump, were many specimens of *L. alta*, and rarely a *Stropheodonta varistriata.*

No other fossils were observed in rocks from below the Oriskany at the Retsof or the Greigsville shafts.

At the Lehigh shaft, the next rock below the Oriskany was a yellow gray limestone, saturated with petroleum.

In the upper part of this layer, a *Favosites*, with fine cells, was quite abundant, sometimes in large masses. No other fossils were observed from this horizon or below.

In an old quarry, two miles southeast of the village of Phelps, I found a good specimen of *Eurypterus lacustris* in a thin layer of water limestone about twenty-five feet below the Oriskany sandstone.

The alternating layers of limestones and bluish-gray gypsiferous shales or marlytes, which lie between the Lower Helderberg group and the salt beds, are quite uniform in character and appearance in the Livonia shaft. No red or green shales were found there above the salt, though at the Retsof and Greigsville shafts they were present, and at the Lehigh shaft the first salt was found in a bed forty feet thick, composed of red, green or mottled shale, the top of which is 140 feet above the main salt beds. From the depth of 1,078 feet to the bottom of the shaft, gypsum was more or less abundant in nearly every stratum of rock. The color ranged from pearly-white or transparent to dark reddish-brown.

The limestones were dark-gray, slightly shaded with red or yellow in thin layers usually separated by thin partings of black bituminous matter. Some portions of the rock in which the carbonaceous matter was abundant show many small abrupt curvatures of the laminae, the surface of the layers showing many low, round or oval elevations. The texture was very fine in most of the layers and the rock very hard.

The hopper-shaped crystals were found at three horizons, in the middle of layers about six inches thick, of fine, dark limestone; also, at the Lehigh shaft in a limestone of the same character.

The "needle cavities," mentioned in Vanuxem's Report, Third Geol. Dist. N. Y., occurred at many places in the higher limestone group.

Cell-like cavities in the limestone were first observed at the shaft in the dark gray stratum at 1,302–1,305 feet. They were irregular in shape, with jagged edges, and averaged about half an inch in diameter.

In the vicinity of the salt beds nearly all of the limestones, though heavy and apparently compact when taken out of the shaft, contained a large amount of salt, and when placed in a stream of running water where the salt was dissolved out, the rock quickly became cellular or "vermicular."

The cells were cylindrical in shape and quite uniform in size in the same stratum, but decreased in size from three-sixteenths of an inch in the layers at 1,356 feet to one-sixteenth of an inch in the layers adjacent to the salt beds.

The limestones next to and in the rock salt were not only thoroughly honey-combed by these cells, but were much broken and displaced, the interstices being filled with pinkish salt.

These fractures and dislocations of the strata could be seen in the rocks underlying the salt beds in all of the shafts, and it is probable that the "cavings" and accumulation of "sand," which sometimes are a source of trouble in wells from which brine is pumped, are due to the removal of salt from the veins, thereby loosening blocks and fragments of the limestone and allowing them to crumble.

The shales in and near the beds of salt were soft and fragile and full of thin seams and veins of salt. Even when housed and protected from the influence of sun and rain, a large slab of it would soon crumble to a heap of dust.

The *Salt* in the shales at Livonia was rather loosely crystalline, and cream to pale red in color.

At Greigsville and Lehigh some of the salt, and also the gypsum from the veins in the red and green shales, was very bright red. The salt in the limestone was clear and transparent, or nearly so.

The top of the first bed of rock salt in the Livonia shaft is 1,369 feet from the surface and 503 feet below the top of the Corniferous limestone.

In the Retsof shaft it is 583 feet from the top of the Corniferous to the salt beds, and in the Lehigh shaft 597 feet.

In the records of the wells in the Oatka valley the figures given would show a distance varying from 575 feet at Gainesville creek and 577 feet at Le Roy to 660 feet at the Bradley wells.

On the west side of the Genesee valley the figures range between 57[illegible] feet for the well at York to 640 feet in the Phœnix well.

In the Lakeville well, according to the record, it was 470 feet; in Townsend's well, north of Livonia station, 490 feet; and in the test well near the shaft, 503 feet.

From this it might be thought that the Livonia beds are not continuous with those further west, but high in the strata and local, but the test well which was put down 400 yards north of the Livonia shaft, was sunk through the two salt beds to a depth of 675 feet below the top of the Corniferous and 114 feet below the second salt bed and no other beds were found. The rock below the second salt bed was all soft shale.

Although it is more than probable that the figures in the well records, excepting the total depth of the wells, are in most cases approximations and not the result of accurate measurements, and therefore are not to be implicitly relied on to show the condition of the upper surface of the salt beds, the fact that it is very uneven and broken however and not at all conformable for any distance with the overlying rock strata is shown in all of the mines.

The line of contact between the rock and the salt is generally well defined, but full of curvatures, some of which are very abrupt.

Fragments of the rock appear to have become detached and sunk down into the salt and the spaces left are filled with salt.

The general character of the salt beds is the same at all of the mines.

The upper part of the upper bed contains more or less clayey shale not in layers, but in fragments and occasionally large masses mixed with the salt in such a manner that no lines of deposition appear. In some places this "mixed salt" is very clear and entirely free from rock, in others the proportion of rock is considerable.

The depth to which this condition extends varies greatly and abruptly. In some places it affects but a few feet and at others reaches almost to the bottom of the bed.

In the lower part of the upper bed the salt is stratified, and the nearly level lines of deposition are very distinct, as the layers vary from transparency or opaque white to gray. The crystals are smaller and the whole mass is compact in appearance and nearly uniform in character.

This bed of homogeneous salt rests conformably on a stratum of limestone which appears to be persistent, and throughout nearly the whole of the salt field separates the two principal beds of salt. This rock shows many fractures and is full of thin seams and veins of salt, but has not been very much disturbed from its original position and condition. It dips toward the west at the rate of eight to twelve inches in 100 feet in the Livonia mine. If the salt beds have the same inclination, they would reach the level of the beds in the Genesee valley in four or five miles. This interstratified bed of rock is only seven and one-half feet thick in the Livonia shaft, while in the Genesee valley the records show it to be twenty to thirty feet thick.

At the Lehigh shaft the rock beneath the stratified salt was two feet thick.

The records of the wells in the Warsaw district give very little information on this point.

In the Warsaw company's well the two beds of salt were separated by ten feet of shale, in the Kerr wells by thirty-one feet, in the Duncan well by forty-five feet and in the Gainesville well by twenty-eight feet.

The lower bed of salt is fifteen and one-half feet thick at Livonia, seven feet at the Lehigh shaft and fifty-eight feet at the Retsof shaft. It was not reached in the Greigsville shaft. It is all "mixed salt," and in quality and condition is like the upper part of the upper bed. It is not worked in any of the mines. The total thickness of the rock salt beds, including the intercalated layers of rock, is fifty-seven and one-half feet at the Livonia, 110 feet at the Retsof and thirty-three feet at the Lehigh shaft.

According to the well records, the thickness is seventy to seventy-five feet at Lakeville, twenty-five feet at Caledonia, seventy-eight feet at York, 108 feet at the Genesee wells, 123 feet at the Livingston, 118 feet at the Lackawanna and 128 feet at the Royal wells.

In the Oatka district it is forty feet in the Junction well, eighty-five feet in Moulton's, seventy feet in the Pioneer, sixty-one feet in the Crystal, eighty-five feet at Miller's, fifty-seven feet at the Atlantic, eighty-six feet at Warsaw, sixty-eight feet in Dr. Gouinlock's, forty-two feet in Gouinlock & Humphrey's, fifty-four feet in the Bradley, ninety-six feet in the Kerr, 130 feet in Duncan's, ninety feet in the Castile, sixty-four feet in the Gainesville and fifty-six feet in the Bliss wells.

At Perry they are fifty-five feet, at Dansville sixty feet, and at Naples sixty-three feet thick.

Mr. Donohue, who had charge of drilling Empire well No. 2, informed me that about 100 feet above the main salt bed he found a three inch layer of salt, and in sinking well No. 3, some distance away, found at the same depth the cavity made by the dissolution of the salt, showing that the layer was of some extent.

I have not learned of any other layer of salt that does not appear to belong to the beds described. The counties of Genesee, Wyoming and Livingston embrace all the territory overlying that part of the great salt bed of the Salina group which has been developed for the production of salt for commercial purposes in Western New York, but the deep borings at Dansville, Naples, Dundee, Watkins, Ludlowville and Ithaca have demonstrated the continuity of the beds; and the Western New York salt fields may be said to extend to Seneca lake on the east, thus including Ontario and Yates counties.

The wells on the west side of the valley at Warsaw are the most westerly ones in which rock salt has been found, so far as is certainly known, but the thickness of the beds of salt found there would lead to the presumption that they extend considerably further in that direction.

The elevation of the strata on the north brings the horizon of the salt beds to the surface (when not covered by the drift) in a narrow belt extending in an easterly direction across the north part of Genesee county and the southern part of both Monroe and Wayne counties, where springs of brackish water are of frequent occurrence, and brine of considerable strength has been found in many wells drilled into rock, but there is no record that rock salt has been found north of the line of outcrop of the top of the Corniferous limestone which is exposed at Batavia, Stafford, Le Roy, Caledonia, Avon, Mendon, Victor, Farmington, Manchester and Phelps, and may be considered to be the northern boundary of the salt district.

The southern boundary of the salt field is not well established. In the deep wells at Gainesville creek, Castile, Nunda, Dansville, Naples, Dundee and Watkins thick beds of clear salt were reached, and it is probable that they extend much further toward the south, though the elevation of the surface and the dip of the strata put them beyond reach for commercial purposes.

The Oatka valley, or Warsaw salt district, embraces the territory drained by the Oatka river between Le Roy and the headwaters of that stream, and is wholly within the limits of Genesee and Wyoming counties.

The geological position of the mouths of the salt wells in the district is as follows: The first rock reached in the wells of the Le Roy Salt Company, near the village, belongs to the Marcellus group or to the lower shales of the Hamilton group.

The horizon of the mouth of the Lehigh shaft is in the soft gray Ludlowville shale, 122 feet above the bottom of the Hamilton group.

In the well known as the Junction well, forty-six feet of drift and 132 feet of the lower Hamilton shales were passed through.

The horizon of the mouth of the well at Pavilion is very closely that of the top of the Hamilton, as exposed half a mile north. The top of the Corniferous limestone was reached in this well at 425 feet from the surface. If sixty feet be allowed for the Marcellus shales, there would remain as the thickness of the Hamilton strata, 365 feet.

The mouth of the Pearl Creek well is about fifty feet above the bottom of the Genesee.

In the Moulton well, after passing through fifty-three feet of drift, the Genesee slate was reached about fifty-nine feet above the base of the group.

The well of the Globe Salt Company is situated at the mouth of a ravine near the village of Wyoming, where sixty to seventy feet of the soft olive shales of the Cashaqua division of the Portage group, with the characteristic fossils more than ordinarily abundant, are well exposed in the sides of the gulch and along the bed of the stream. The "second black band" is exposed about half a mile up the ravine. The mouth of the well is about sixty feet above the bottom of the lower black band, which is the base of the Portage group.

The Pioneer well, in which rock salt was first reached in the State of New York, was drilled at the mouth of a small ravine about a mile south of the village of Wyoming, on the west side of the valley. After passing through forty feet of intermingled clay and broken shale, forty feet of bluish Portage shales were penetrated, and at least fifty or sixty feet at the top of the "220 feet black shales" in the record, belong to the lower black band of the Portage group.

Well No. 1 of the Crystal Salt Company at Saltvale has 136 feet of drift overlying the first rock, which is soft shale, about forty-two feet above the bottom of the Portage.

The wells of the Miller Salt Company, the Atlantic Salt Company and the Warsaw Salt Company were begun in the "Gardeau" flags and shales of the Portage epoch from 319 to 334 feet above the bottom of that group, and Dr. Gouinlock's well (east side) passes through at least 400 feet of Portage rocks. The Gouinlock & Humphrey wells, on the west side of the valley near the Erie tracks, and those of the Hawley Salt Company, one-fourth mile south, were begun in the thin sandstone of the upper Portage and sunk through from 600 to 625 feet of the

PLATE 2.

LIVONIA SALT AND MINING COMPANY. THE BREAKER-HOUSE, LOOKING SOUTH.

strata of that group. The horizon of the mouth of well No. 1 of the Empire Salt Company is not far from 750 feet above the base of the Portage group, and that of the Bradley (formerly Eldredge) Company 675 feet.

The quarries of the Warsaw Stone Company, at Rock Glen, are one-half mile northwest of the Kerr Salt Company's wells, in the thick beds of bluish gray sandstone, which is regarded as marking the close of the Portage epoch. Their total thickness is here thirty-two feet three inches. The upper surface of the bed is thirty feet below the level of the tracks of the Lake Erie and Western railroad, by the side of which the quarries are situated. The grade between the Kerr wells and the railroad at a point opposite the quarries is very slight, and the dip of the strata probably not more than fifteen feet. The horizon of the mouth of the well of the record is fifteen feet above the bottom of the Chemung group.

The following wells belong to Prof. Bishop's "Ridge group." They are located in the southeastern part of Wyoming county. The drainage is through East Coy creek, West Coy creek and Wolf creek into the Genesee river.

If bed rock were found at the surface at the Duncan wells at Silver Springs, it would be about 135 feet above the base of Chemung group.

The well at Gainesville creek, with 358 feet of drift, reaches Chemung rock at about forty feet above the base of that group.

The Castile well, with forty-nine feet of drift, has 130 feet of Chemung rocks.

The well at Bliss, the most southerly one in which rock salt has been reached west of the Genesee river, has a surface altitude of 1,729 feet, passes through about 600 feet of Chemung strata, reaches the "flint" (Corniferous) at 1,995 feet, and a fifty-six foot bed of rock salt 900 feet lower and 2,895 feet from the surface.

The well at Perry was begun in the upper part of the Portage rocks, and passes through about 730 feet of that group.

The Genesee salt district lies in the territory drained by the Genesee river in Livingston county.

The most northerly salt well in the Genesee district is the well at Teazle hollow, in Caledonia, which begins in the black Marcellus shales, just below the horizon of the Stafford limestone.

The first rock reached in the York Salt Company's well at York, after passing through fifty-two feet of alluvium, is the soft Ludlowville shale, about sixty feet above the bottom of the Hamilton.

The Retsof shaft was begun, not on the limestone of the encrinal band, but 133 feet above it on a layer of fine hard limestone eight to ten inches thick, which is probably identical with the one occurring in the Livonia shaft at the depth of 438 to 440 feet from the surface. Like most of the calcareous layers in the Hamilton group, it contains many sections of crinoid columns as well as other fossils.

The horizon of the mouth of the shaft of the Greigsville Salt Mining Company, which is situated about one mile west and one-fourth mile south of the Retsof shaft, is twenty feet below the top of the Hamilton group. One of the patches of the iron pyrites which lie between the Genesee and Hamilton shales was exposed in a shallow excavation in the side of the hill about twenty-five rods west of the shaft. The surface elevation is ninety feet greater at the Greigsville shaft than at the Retsof.

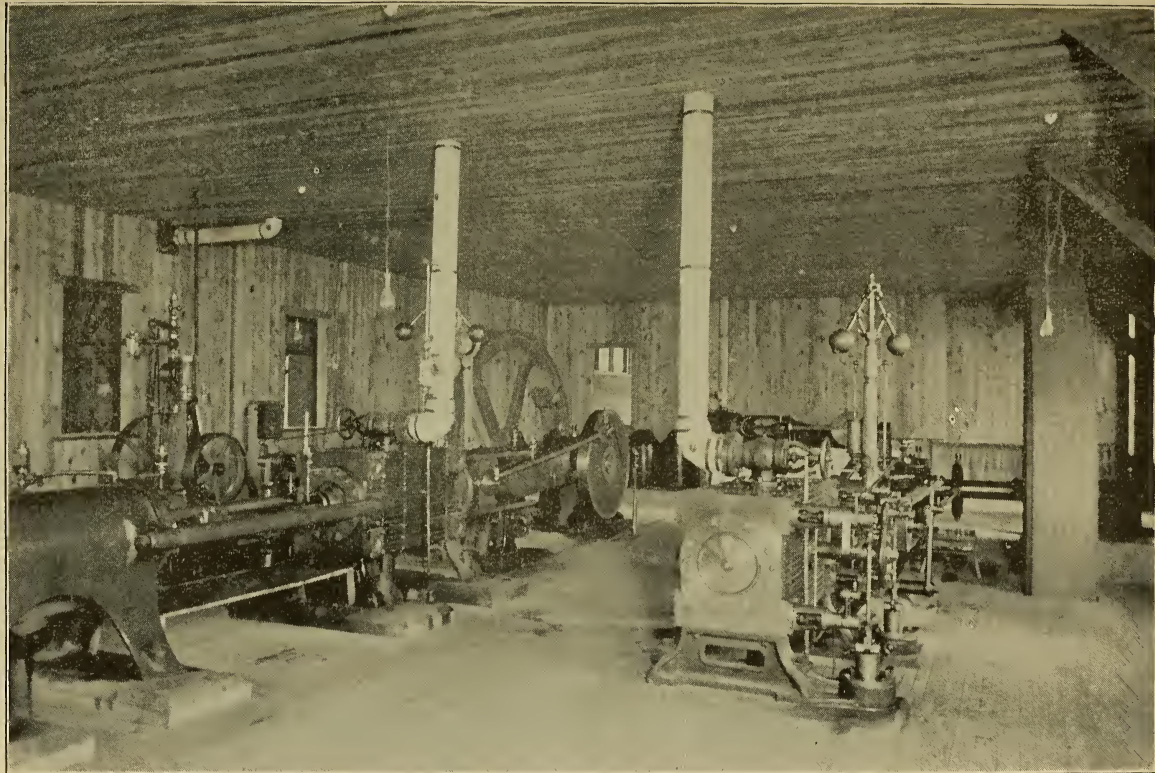
The Livingston Salt Company's wells, at Piffard, pass through 186 feet of alluvium, and reach rock at about ten feet above the bottom of the Hamilton.

The Genesee Salt Company's wells, one-half mile south of the Livingston wells, reaches rock at sixty-four feet from the surface, about 120 feet above the bottom of the Hamilton group in the Ludlowville shales.

The Phœnix wells, at Cuylerville, penetrate one hundred and eighty-four feet of loam, sand and clay, reaching rock near the horizon of the Encrinal band of the Hamilton group. The mouths of the wells of the Lackawana company are about on the Styliola band of the Genesee group and the Royal Company's wells, are a few feet higher than the Styliola limestone.

The Nunda and Dansville wells are started in the shales and flags of the upper part of the Portage group.

PLATE 3.



Livonia Salt and Mining Company. At the Left the Air-Compressor to Drive Drills in the Mine; at the Right the Breaker Engine, 125 Horse-power, to Drive Crushers and Screens.

The perpendicular opening in the rocks from the surface to the bed of rock salt, technically called the shaft, is the only avenue of communication between the mine and the outside world.

Not only must all the machinery and materials for mining the salt and the salt itself be transported through it, but it is the only means of ingress and egress for the men employed in working the mine. It is therefore of the utmost importance to the success of the enterprise financially and to the safety of the lives of the miners that every element of danger in the passage of men or material through the shaft be reduced to its minimum.

Perhaps the greatest danger, if not guarded against, would arise from the tendency of some kinds of rock to disintegrate, or become weakened on exposure to the atmosphere, and allow fragments to become detached and fall down the shaft, the great depth of which would give them the velocity of a bullet.

In the Livonia shaft all of the rock above the Corniferous limestone, 802 feet, was, with the exception of a few thin layers, soft shale that crumbled quickly on exposure and was full of joints or "slips," *i. e.*, thin vertical seams filled but not cemented by almost transparent calcium carbonate, making very dangerous "ground," and it was necessary that the shaft be not only "timbered" but "lined" also, which was done with the greatest care and the very best material obtainable.

The method of timbering and lining in the Livonia shaft is as follows:

When the rock in the bottom of the shaft had been excavated by the process briefly described on a preceding page to a depth sufficient to avoid danger from the blasting, "hitches" were cut into the sides of the shaft one to two feet deep, in such shape as to make a flat shoulder of solid rock to support the "bearers."

These bearers, four in number, are of carefully selected white oak, twelve by fourteen inches in size, for those placed at the ends of the shaft, and ten by fourteen inches for the other two, and are long enough to reach across the shaft and to the full depth of the hitches, where they are solidly fastened by means of keys and wedges.

They are all in the same plane and so placed as to divide the shaft into three compartments of equal size.

Sets of these bearers are put in usually about thirty-five feet apart in soft rock.

Resting upon the bearers, the "wall plates," ten by ten inches, of the best hard pine, framed together, are put in position at the sides and ends of the shaft with the "dividers," eight by ten inches for the partition. When these have been securely fastened by means of wedges, "studdles," ten by ten inches, four feet two inches long, are placed on end at each corner, and at the ends of the dividers, and upon these studdles another set of wall plates and dividers is placed.

On the back side of the timbers two-inch planks are fastened in a vertical position, and the space between them and the rock wall filled in with broken rock from the bottom, then other sets are put in in the same manner until the space is filled to the top.

Afterward the "guides" are put into the two compartments designed to be used in hoisting, and then all of the three compartments are lined with one and one-quarter inch planks.

The guides are clear, hard pine timbers, five by eight inches, bolted to the center of the sides of the compartments, and carefully joined at the ends so as to extend continuously from the bottom of the shaft to the top of the building, and serve to hold the cage steady while ascending or descending.

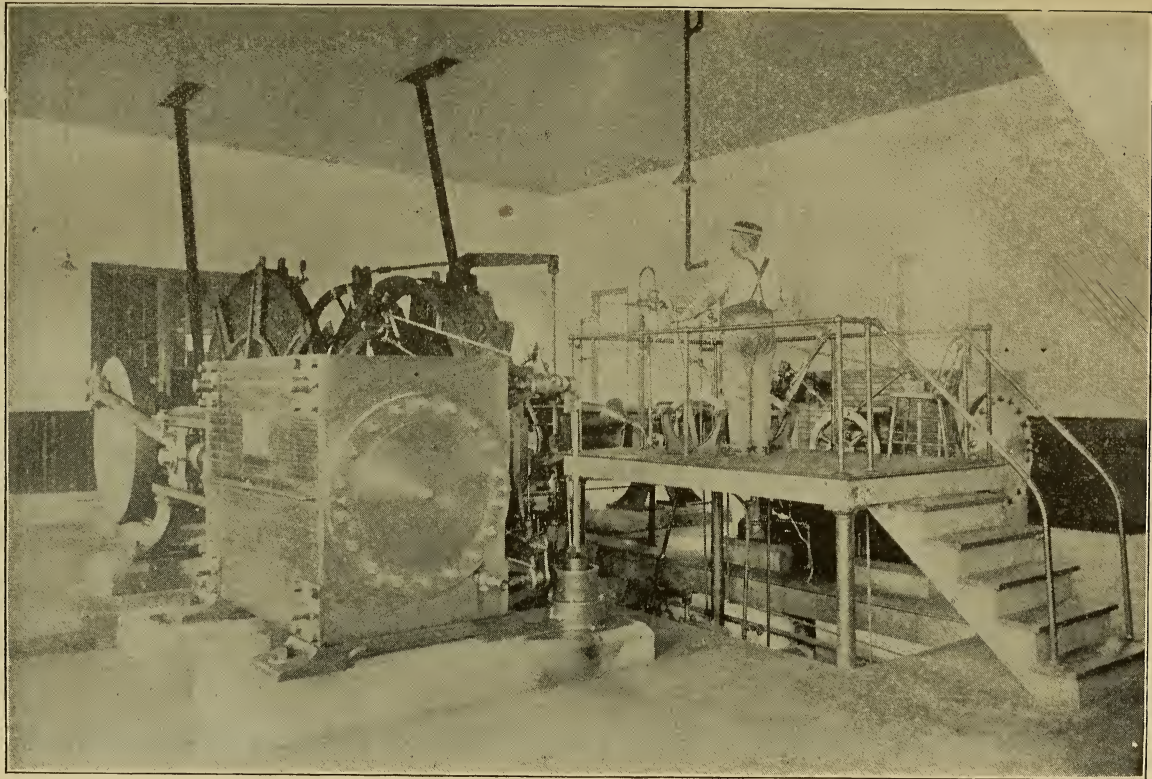
In the third compartment are placed the ladders, a succession of which reach from the bottom to the surface, to be used in case of emergency.

The speaking tubes, compressed air pipes, bell wires and electric-light wires are also in this compartment, and a part of it is partitioned off for a fresh-air shaft connected with a fan at the surface.

About 100 feet from the surface and next to the ladder shaft is the cistern, excavated from the rock, and capable of holding 400 to 500 barrels, into which the water from the drift and the upper part of the rock which finds its way into the shaft is collected by means of gutters, and from which it is pumped to the surface.

A smaller cistern is located about 1,100 feet from the surface to collect the bitter water which percolates through the dark brown sandy rock at 1,045 feet.

PLATE 4.



Livonia Salt and Mining Company. Hoist-engine, 1,000 Horse-power, Two Cylinders with Steam Brake. Hoisting Cable, 6″ × ½″.

These two cisterns are sufficient for the water which comes into the shaft, and none are required in the mine, as the salt beds are dry. The sinking of the shaft through the salt beds had furnished opportunity for a thorough examination of their quality and the bottom of the upper salt bed was fixed upon for the floor of the mine. A platform was built at that level 1,403 feet from the surface and "stations" cut in the east and west walls of the shaft, where the main gangways were to be driven, then work was suspended in the bottom, the old head house and hoisting machinery removed, and the erection of the permanent buildings and the placing of the permanent machinery for operating the mine were pushed to completion.

The principal building is 112 feet long by about forty feet wide. The east end, which is directly over the shaft, is 140 feet high, constructed of very heavy timbers and is a continuation of the two compartments of the shaft used for hoisting, so that cars may be hoisted to the top of the building and the salt descend by gravity through the crushers and sieves which are located on the upper floors of this building. Attached to the breaker building on the south is the stock house, 150 feet long by thirty-three feet wide, used for sacking and storing the finer grades of salt. It is a frame building one story high. On the north side, opposite the shaft and attached to the main building, is the machinery building, 112 feet by thirty-six feet, in the north end of which is situated the machine shop, which is partitioned off from the engine room and is provided with the machinery required in working iron and steel. The south end contains the 100 horse power Corliss breaker engine, which drives the crushers and sieves, the fifty horse power engine that drives the sixteen foot fan that, when required, is used to supply fresh air in the mine.

The sixty horse power air compressor, capable of driving twelve to fifteen Howell rotary auger drills, is also in this room, and the ten horse power upright engine that drives the dynamo for the electric lights which are used throughout the buildings and to light the mine.

About twenty feet east of the shaft is a brick and stone building eighty-four feet by forty-five feet, which contains the hoisting engine that when in action develops 1,000 horse power and drives the eight foot drum on which is wound the flat steel wire cable, six inches wide by three-quarters of an inch thick, from which is suspended the "cage" or platform used in hoisting the carloads of salt. North of the engine house is the boiler house, a detached building forty-five feet by ninety feet, built almost entirely of brick and stone. It contains the boilers which furnish the steam required for all of the engines and steam pumps used at the works. The blacksmith shop is also in the building. On the outside of the boiler house, and extending its entire length, are the coal bins, under a trestle connected at grade with the Lake Erie and Western railroad tracks. Nearly 25,000 gallons of water per day are required to supply the boilers. This is obtained ordinarily from the small stream which runs through the company's land, but to provide in case of the failure of that source, pumping works have been established at the nearest point on Conesus lake capable of elevating any amount of water likely to be required through iron pipes into a reservoir with a capacity of 90,000 gallons, which is situated on a hill near the shaft and is about 400 feet higher than the lake. It is also higher than any of the company's buildings, except the tower of the breaker building. Hose connected with the reservoir is conveniently placed in every part of the buildings for use in case of fire.

Besides the buildings described are the offices, the carpenter shop, stables, etc., near the shaft, and on another part of the company's land the boarding-houses and cottages for the employés.

As the mine itself is developed it becomes a series of long rooms fifty feet apart, thirty feet wide and parallel to each other, which open into the main gangway that extends east and west from the bottom of the shaft. The floor of these rooms is nearly level and tracks are laid in them on which the mining cars, holding from two and one-half to three tons of salt when loaded, are drawn by mules. The height of the rooms depends on the thickness of the homogenous salt, the mixed salt of the upper part of the bed being left for the roof of the mine. As the roof is perfectly dry and firm, no supports for it are required in the rooms. The fifty-foot wall between the rooms is worked out in such a manner as to leave pillars of the rock salt, twenty feet by thirty feet in size, thirty feet apart each way.

PLATE 5.

LIVONIA SALT AND MINING COMPANY. END OF DRIFT IN MINE, WITH MEN DRILLING AND LOADING.

The process employed in breaking down the salt is very simple. Rotary auger drills one and one-half inches in diameter, driven by compressed air, drill vertical rows of four holes each into the breast at each side and about one-third of the distance from the sides; the two middle rows at such an angle that they nearly meet at the bottom of the holes, which are nine feet in depth.

One and one-half sticks, three-fourths of a pound of twenty per cent dynamite are placed in the bottom of each hole and exploded by electricity from a battery in another room, many tons of salt being thrown out by each blast.

The fragments suitable for the grades of "lump" salt are first picked out and loaded into cars, hoisted to the surface and spread out on a large platform to "cure," that is to harden so that they can be handled without crumbling.

After the removal of the "lumps" the remaining salt is shoveled into cars and drawn by mules to the foot of the shaft and on to the cage. This cage, which is suspended from a cross head that glides between the guides previously described, is hoisted with its load to the top floor of the breaker building, ninety feet above the surface and 1,490 feet above the bottom, in less than fifty seconds as an average. Here the salt is dumped from the cars and passes into the first rolls or breaker and is partially crushed. It then goes down an incline arranged for convenience in picking out fragments of slate and on to a set of sieves, where the smaller crystals are sifted out and graded, the coarser part of the mass passing over the sieve and into another set of rolls smaller than the first and another set of sieves; and this process is again repeated, there being three sets of rolls and sieves.

From the sieves each grade is conveyed or spouted into large bins, so situated that the salt may be drawn through spouts directly into a car, or the stock house, when it is to be put into sacks or barrels.

Mineral salt prepared for market is graded as follows:

"Large lumps," 50 to 200 lbs. in weight, used in the Western States for "cattle licks."

"Small lumps," 5 to 50 lbs., also used principally in the Eastern States, for cattle.

"No. 4," which passes *through* a sieve having apertures $\frac{3}{4}$ inches in diameter, and *over* one with $\frac{3}{8}$ inch holes.

"No. 3," passes *through* $\frac{3}{8}$ inch sieve and *over* $\frac{5}{16}$ inch.
"No. 2," passes *through* $\frac{5}{16}$ inch sieve and *over* $\frac{3}{16}$ inch.
"No. 1," passes *through* $\frac{3}{16}$ inch sieve and *over* $\frac{1}{8}$ inch.
"C," passes *through* $\frac{1}{8}$ inch sieve and *over* $\frac{1}{16}$ inch.

These grades are used in refrigerators, for curing hides, for packing and pickling beef, pork and fish, and for brine making generally.

"O" or "dust salt" is the fine particles remaining after the other grades are separated, and is used in the manufacture of carbonate of soda, bleaching powder, soap, etc., and for agricul tural purposes.

It had been expected that the sinking of a second shaft a short distance from the one described in this report would give opportunity for obtaining exact figures for the thickness of the strata in the upper part of the section, but the second shaft though begun, has not yet been sunk to the rock.

The accompanying diagram of the rock section from the surface to 380 feet below the surface was prepared from data obtained by a study of the nearest outcrops of rock, and the large amount of material which had been hoisted out previous to the beginning of the record.

The *debris* had been so deposited on being brought to the surface that it was not found difficult to determine in a general way by examination, and by aid of information derived from the superintendent and others, the relative position of the strata passed through.

There are no rock exposures in the immediate vicinity of the shaft, a small one-half a mile west being the nearest.

About two miles distant, on the west side of Conesus lake, are several ravines in which the lower Portage and upper Genesee shales are well exposed. The lower Genesee beds, including the Styliola layer and the upper Hamilton shales, are exposed along the outlet of Hemlock lake and at Richmond Mills, four to five miles east, and at several places in the vicinity of Geneseo on the west.

Careful examinations were made of the outcrops mentioned and as accurate measurements of the strata obtained as possible.

By a series of levelings from a fine exposure in the ravine at Eagle point, two miles west of the shaft, of the easily recognized

PLATE 6.

Livonia Salt and Mining Company. Men Drilling and Loading Holes with Dynamite. Broken Salt in Front.

limestones of the Styliola band of the Genesee group, the position of the band was found to be approximately 190 feet below the surface in the shaft.

At the falls in Fall Brook glen, near Geneseo, the top of the Styliola band is eighty-three feet above the thin layer of iron pyrites which separates the Genesee and Hamilton groups, while on Canandaigua lake it is about 110 feet above it.

Ninety feet is assumed, therefore, as the thickness of the rock between the Styliola band and the top of the Hamilton group in the shaft and 280 feet as the depth at which the Hamilton group was reached.

The diagram of the rock section in the Retsof shaft was prepared from the record mentioned, with some slight changes which examinations of outcrops in the vicinity and information obtained at the Greigsville shaft appeared to make proper.

The Retsof shaft at the surface is about ninety feet lower than the Greigsville shaft, and 110 feet below the top of the Hamilton group, as was shown by the exposure of the pyrites layer, here four inches thick, and the upper layers of the Moscow shale, in a shallow excavation a short distance west of the Greigsville shaft and about twenty feet higher than its mouth.

The limestone in which it begun is one of several which occur in about this horizon, and is not the limestone of the encrinal band, as that was reached at a depth of 133 feet.

In the preparations of the diagrams, showing the relative position of the wells in the Genesee and Oatka valleys, the well records, as published in the reports of Prof. I. P. Bishop, Dr. Englehart and Prof. Merrill, have been used.

The facts given in regard to the geological position of the mouths of wells were ascertained by several weeks' study of the many exposures in the ravines through which the little streams which lead into the Genesee or Oatka rivers have cut their way.

As the Livonia shaft, a majority of the wells in which rock salt has been reached in the Warsaw district, and the wells at Attica, Castile, Perry, Nunda, Dansville, Naples and Dundee are all located on rocks of the Portage group, three sections have been prepared which show the strata as they are exposed in Yates, Ontario, Livingston and Wyoming counties.

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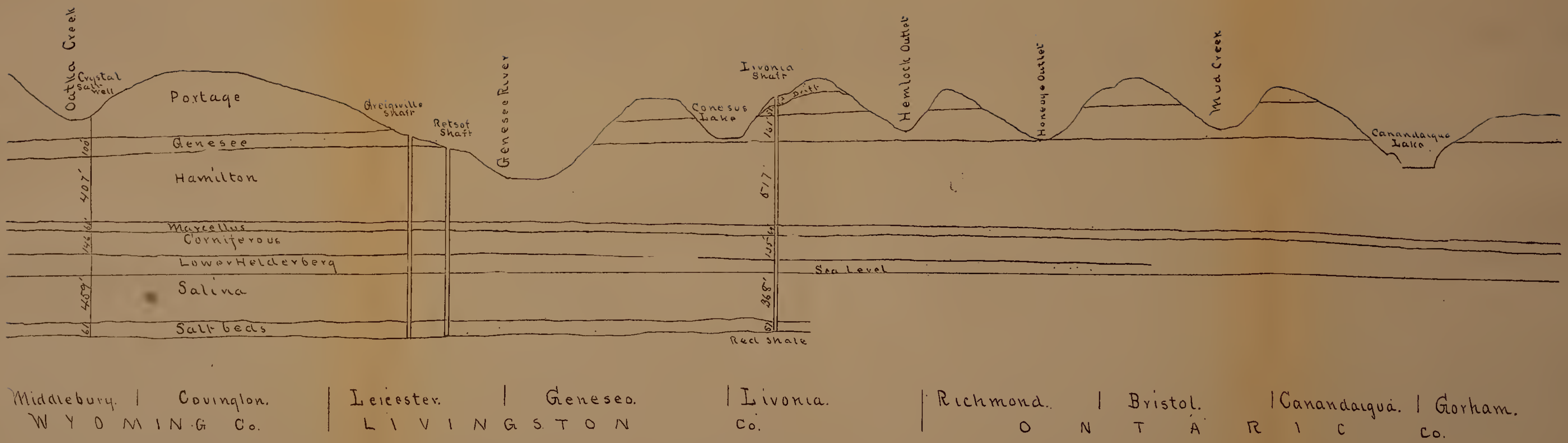
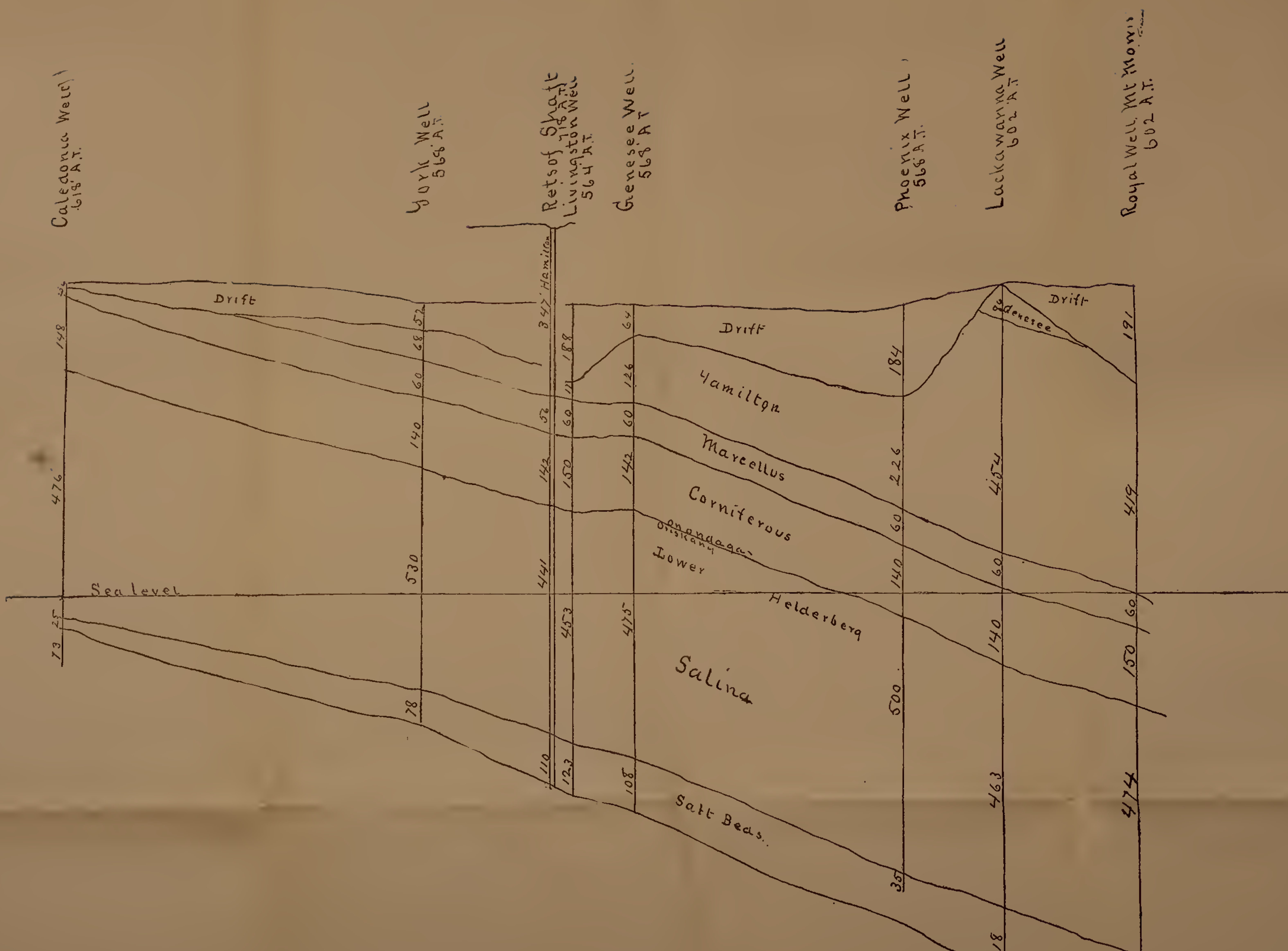


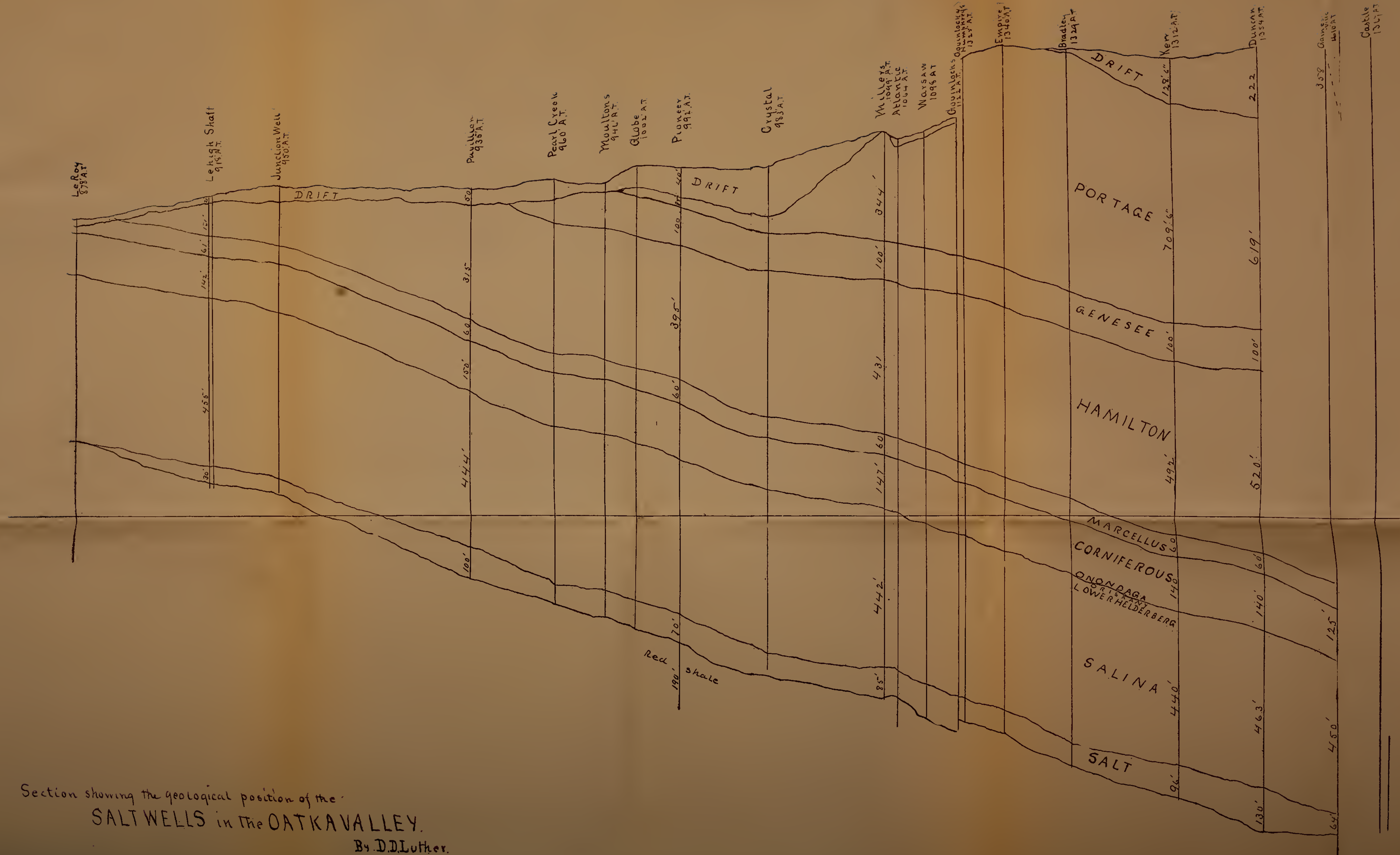
Profile and Section on east and west line through Livonia Salt Shaft.
By D. D. Luther.



Section showing the geological position of the

SALT WELLS in the GENESEE VALLEY.

By D.D.Luther.



Section showing the geological position of the
SALT WELLS in the OATKA VALLEY.
By D. D. Luther.


LIVONIA SALT SHAFT.
KETSOF SALT SHAFT.
LEHIGH SALT SHAFT.
Drift
Portage.
Hamilton.
Marcellus.
Corniferous.
Lower Helderberg.
Salina.
Blue shales.
Encrinal band.
Lower Hamilton shales.
Dark shales.
Limestone and chert.
Water-lime.
Gypsum beds.
Shale.
Stafford limestone.
Cement, etc.
Gypsum.
Magnesian limestone.
Salt
Limestone with cavities.
Red, blue and green marlytes, with salt in veins.
Limestones and blue marlytes, salt in veins.
Sea level.
Sea level.
Vertical scale, 50 feet to the inch.

Salt Wells in Livingston County.

Vertical Scale, 150 feet to the inch.

Salt Wells in Oatka Creek Valley.

Vertical Scale, 150 feet to the inch.

RECORDED SECTION OF LIVONIA SHAFT.

380′

6′ Bluish gray shales, quite soft, breaking easily across the lines of deposition, and crumbling into a mass of small angular fragments on exposure. Thin calcareous layers made up of crinoid columns, mainly, but containing many other fossils, occur frequently. Fossils are moderately abundant in the shale also. Fine large specimens of *Phacops rana* with *Homolonotus DeKayi*, *Cryphœus Boothi*, *Platyceras subrectum*, *Actinopteria decussata*, *Pterinopecten undosus*, *Spirifer mucronatus*, *Sp. divaricatus*, *Athyris spiriferoides*, and others, are common.

Thin limestone with crinoid heads and columns and other fossils.

386′

29′ Compact dark blue shales, which on weathering become light bluish gray, with a blocky fracture. The upper part of the bed medium soft, below 400′ harder.

Fossils are to be found in small numbers all through the mass.

Phacops rana, very large, but not common, also a few specimens of *Homolonotus DeKayi* and *Cryphœus Boothi* were found.

Other fossils are *Diaphorostoma lineatum*, *Platyceras subrectum*, *Pleurotomaria capillaria*, *P. rugulata*, *Bellerophon patulus*, *Actinopteria decussata*, *Liopteria Conradi*, *Spirifer fimbriatus*, *Spirifer mucronatus*, *Athyris spiriferoides*, *Tropidoleptus carinatus*, *Chonetes scitula*, *Lingula punctata* and rarely, a bryozoan.

....

....	......	....
415′		1′ Hard gray limestone with few fossils.
416′		11′ Hard medium dark blue shales, somewhat calcareous, with softer layers. Corals are quite common, other fossils rare. *Heliophyllum Halli*, *Striatopora limbata*, *Orthoceras exile*, *Pterinopecten undosus*, *Stropheodonta inequistriata*, *Orbiculoidea media*, and a few others occur.
427′		2′ Blue gray limestone with several species and many individual specimens of coral. Other fossils very rare.
429′		1′ Soft blue gray shales. *Lingula spatulata* abundant. Several species of Gasteropoda, *Phacops rana*, *Strophodonta Junia*.
430′		1′ Fine pinkish-gray limestone, — not many fossils. A few brachiopods.

431′		7′ Blue shales with concretionary layers; not many fossils. *Heliophyllum Halli*, *Favosites Canadensis* and other corals occur in the hard layers, and *Phacops rana*, *Stropheodonta perplana*, *Orthis Penelope*, and a few other species.
438′		2′ Hard limestone containing considerable pyrites. Very few fossils.
440′		7′ Soft blue compact pyritiferous shales containing a few cyathophylloid corals and bryozoans, other fossils being quite rare. At 443′ several specimens of *Goniatites uniangularis* in pyrite were found.

447′ 20′ Soft blue-gray shales, compact, with occasional fine sandy layers, slightly calcareous. Small amount of gas. Fossils abundant. The most common species are: *Phacops rana*, *Proetus Rowi*, *P. macrocephalus*, and *Homalonotus De Kayi*, *Goniatites uniangularis*, *Pleurotomaria Itys*, *P. capillaria*, *Loxonema Hamiltoniæ*, *Platyceras Thetis*, *Styliolina fissurella*, *Actinopteria decussata*, *Lyriopecten orbiculatus*, *Modiomorpha mytiloides*, *Aviculopecten princeps*, *Pterinea flabella*, *Orthoceras nuntium*, *Nautilus magister*, *Spirifer mucronatus*, *Sp. audaculus*, *Athyris spiriferoides*, *Orthis Vanuxemi*, *Stropheodonta concava*, *S. perplana*, *S. inequistriata*, *Chonetes scitula*, *Tropidoleptus carinatus*, *Crania Hamiltoniæ*, *Ambocœlia umbonata*, *Meristella Haskinsi*.

Bryozoans are also common.

Crinoids rare.

....

467′		9′ Dark blue slightly pyritiferous shales. Fossils fairly abundant. *Cryphæus Boothi* quite common. Many specimens of orthoceratites in pyrite occur; and several species of coral were collected.
476′		2′ Concretionary layer, with silicified fossils. *Ambocœlia umbonata, Spirifer audaculus, Athyris spiriferoides, Loxonema Hamiltoniæ.* Corals.
478′		17′ Blue shales, quite hard, calcareous, with occasional small concretions in the upper part of the bed, which usually contain gasteropods and a few other fossils. In the shales fossils are quite abundant, some of the most noticeable forms being *Phacops rana, Orthoceras Oedipus, O. nuntium, Goniatites Vanuxemi* (?), *Bellerophon Leda, Pleurotomaria Lucina, Loxonema Hamiltoniæ, Cypricardella bellistriata, Modiomorpha mytiloides, Actinopteria decussata, Palæoneilo constricta, Plethomytilus oviformis, Lunulicardium fragile, Tropidoleptus carinatus, Chonetes lepida, Ambocœlia umbonata, Orbiculoidea media, Athyris spiriferoides, Productella spinulicosta, Stropheodonta perplana, Spirifer mucronatus, Pholidops Hamiltoniæ,* and a few corals.

....	......	....
495′		27′ Darker, brownish to nearly black fissile, slightly bituminous, shales, with thin layers of light blue or olive shale intercalated. Toward the bottom of the bed the light layers disappear. Fossils occur sometimes in thin layers, principally in the darker shales, but are not very abundant. *Liorhynchus multicosta, Goniatites uniangularis, Ambocœlia umbonata, Spirifer mucronatus, Modiomorpha subalata, Lunulicardium fragile, Pleurotomaria rugulata,* and a few plant remains were collected.
....	......	....

515′		28′ Dark bluish-gray soft shales, with brownish layers. Fossils common. In the middle and lower part of the bed fine specimens of *Phacops rana* and *Cryphæus Boothi* occur in considerable numbers, this horizon furnishing more of these trilobites entire than any other. *Chonetes scitula, Stropheodonta perplana, Athyris spiriferoides, Liorhynchus quadricosta, Ambocœlia umbonata, Atrypa reticularis, Spirifer granulosus, Orbiculoidea media, Lingula læana, Modiomorpha subulata, M. mytiloides, Palæoneilo fecunda, Aviculopecten exacutus, Panenka æquilatera, Lunulicardium fragile, Nuculites triqueter, Goniatites uniangularis, Orthoceras exile, Pleurotomaria Itys, Bellerophon Leda.* Corals rare. A few specimens of plant remains. Concretions occur sparingly down to 535′.

....	......	....
543′		4′ Soft, bluish pyritiferous shales. *Goniatites uniangularis* in pyrite are quite common.
547′		8′ Harder, slightly arenaceous and pyritiferous shales, in which corals are very abundant, especially in the lower part of the bed, and brachiopods are common. Other fossils also occur. *Heliophyllum Halli, Striatopora limbata, Streptelasma rectum, Favosites Canadensis, Spririfer granulosus, Sp. mucronatus, Sp. fimbriatus, Sp. divaricatus, Atrypa reticularis, Stropheodonta perplana, S. concava, Modiomorpha mytiloides, Lunulicardium fragilis, Palæoneilo constricta, Actinopteria decussata.*
555′		5′ Sandy shales with thin layers of impure limestone. A bed of corals at the top, with a few crinoid columns. Two heads were collected. Many spirifers and other brachiopods, with lamellibranchs of the same species as occur above, also gasteropods and cephalopods in less abundance.

560′		2′ Light gray limestone containing *Phacops rana, Athyris spiriferoides, Productella spinulicosta, Spirifer audaculus, Stropheodonta nacrea, S. concava, Meristella Haskinsi, Orthis Vanuxemi, Chonetes coronata, Rhynchonella Sappho.* Fragments of crinoid columns rare.
562′		4′ Sandy shales, quite hard, with some calcareous layers of the same character as the bed immediately over the limestone, and containing fossils of the same species. Corals predominate. The line of separation between this and the bed below is well defined.
566′		4′ Very fine dark bituminous shale. *Liorhynchus multicosta, Chonetes scitula, Orbiculoidea media, Goniatites uniangularis, Styliolina fissurella, Lunulicardium fragile, Modiomorpha subalata, Modiella pygmæa.* Fragments of columns of a small crinoid, and plant remains.
570′		34′ Soft dark rock, with layers of light blue to olive barren shale, which predominate in the middle of the bed, and in the lower part are about equal in proportion. Joints or cracks frequently filled with a thin vein of calcite are very numerous in these beds. Their principal direction is nearly east and west, but they meet each other at all angles and make dangerous ground for the miners. Taken as a whole, fossils are rare, though a few thin layers are made up of *Liorhynchus multicosta, Ambocœlia umbonata; Spirifer mucronatus, Chonetes scitula, Orbiculoidea media, Productella spinulicosta, Stropheodonta perplana, Lunulicardium fragile, Aviculopecten princeps, Nuculites triqueter, Panenka æquilatera, Paracyclas lineatus,* and *Phthonia nodocostata* are also present, and plant remains are quite common.

604′		6″ Hard, sandy, dark bluish-gray shales. *Liorhynchus multicosta*, *Chonetes scitula*, — plant remains.
604′ 6″		3′ 4″ Soft dark bluish shales. *Orbiculoidea media*, quite common. *Modiomorpha subalata*, *Aviculopecten princeps*, and a few other species occur sparingly.
607′ 10″		1′ 2″ Hard calcareous sandy layer, in which cyathophylloid corals are abundant. A few bryozoans occur, and rarely fragments of small crinoid columns. Brachiopods and lamellibranchs of the same species as in the beds above are common.
609′		6′ Dark bluish soft shales, in which fossils are exceedingly rare. A few specimens of plant remains were found.
615′		11′ Harder, slightly sandy dark blue shales containing very few fossils. *Liopteria lœvis* being the most common. *Lunulicardium fragile*, *Chonetes scitula* and a few other species also occur.

626′		3′ Sandy layer, quite hard, calcareous in the middle. Very few fossils.
629′		21′ Dark brownish and bluish-gray, rather soft, fine shales, with some layers slightly sandy to 638′. Small amount of gas in the shaft. Fossils not abundant, those found being principally from the darker layers. The following were collected: *Goniatites uniangularis*, *Orthoceras sp.?*, *Chonetes scitula*, *Ambocœlia umbonata*, *Panenka æquilatera*, *Palæoneilo fecunda*, *Lunulicardium fragile*, *Orthonota undulata*, *Gomphoceras sp.?*, *Pleurotomaria rugulata* and a bryozoan.

650′		From 650 to 797 (147′) the rock is of the same general character, being a dark brown, sometimes black, shale with lighter bluish or olive layers which are, at times, slightly arenaceous, intercalated at varying intervals. Gas in small quantities was found in nearly every sink. From 650 to 660 the shale is quite hard, and a few thin layers are calcareous. Fossils quite common. *Phacops rana, Cryphæus Boothi, Liorhynchus multicosta, Chonetes mucronata, Liopteria lævis, Panenka æquilatera, Lunulicardium fragile, Goniatites uniangularis, Orthoceras sp.?* A small cyathophylloid coral and plant remains.
660′		24′ Medium hard shales; the dark layers are quite bituminous, the light ones sandy. Fossils of the same species as found in the bed above, are quite abundant in the darker layers.

....	......	....
684′		82′ Dark brown and grayish bituminous shale, quite soft, with joints numerous, and considerable gas. The few fossils that occur are distributed quite evenly through the bed, except that *Chonetes mucronata* and *Liorhynchus limitaris* are very much more abundant toward the base. The other species found are *Chonetes lepida, Ambocœlia umbonata, Goniatites uniangularis, Orthoceras exile, Bellerophon Leda, Pleurotomaria rugulata, Modiella pygmæa, Cardiola Doris? Panenka sp.? Styliolina fissurella,* fragment of small crinoid columns at 748, a minute bryozoan at 735, and unidentified plant remains.
....	......	....

....	......	....
766′		2′ Soft dark shale with calcareous layers. Fossils very rare. A small bryozoan.
768′		12′ Soft gray shales, with dark layers. Fossils rare, except *Chonetes mucronata* and *Liorhynchus limitaris*. *Liopteria lævis* occurs sparingly, also plant remains.
780′		2′ Dark to black bituminous shales containing few fossils.

782′		15′ Nearly all the light gray, non-bituminous barren shale, the darker layers increasing in proportion from 790′ to bottom of the bed. *Chonetes mucronata, Liorhynchus limitaris, Liopteria lævis, Panenka sp.?* *Goniatites uniangularis, Orthoceras sp.?* and fragments of plants, constitute the list of fossils.

797′		15′ Very bituminous shales, with fossils of a few species abundant. From 797 to 803 *Orbiculoidea minuta* occurs in immense numbers. From 805 to 807 *Liorhynchus limitaris* fills the rock and *Liorhynchus lævis* is abundant. *Productella spinulicosta*, *Ambocœlia umbonata*, *Modiella pygmæa*, *Goniatites uniangularis* *Orthoceras subulatum*, *Styliolina fissurella*, *Pleurotomaria rugulata* and *Bellerophon Leda* are also found.
812′		11′ Black bituminous shale, with blue-black calcareous layers. Fossils abundant. *Liorhynchus limitaris* (in layers), *Productella spinulicosta*, *Strophalosia truncata*, *Ambocœlia umbonata*, *Orbiculoidea minuta*, *Goniatites uniangularis*, *Orthoceras subulatum*, *O. nuntium*, *Pleurotomaria rugulata*, *P. capillaria*, *Lunulicardium fragile*, *Liopteria lævis*, *Panenka æquilatera*, *P. Lincklœni*, *Actinopteria muricata*, *Modiomorpha subalata*. A minute bryozoan on a goniatite, also plant remains.

823′		2′ Compact gray limestone, upper part shaly, slightly bituminous. Fossils abundant. *Phacops rana, Cryphœus Boothi, Rhynchonello Sappho, R. Hosfordi, Strophalosia truncata, Productella spinulicosta, Meristella Barrisi, Ambocœlia umbonata, Pleurotomaria Itys, P. sulcomarginata, P. Lucina, Loxonoma delphicola, Orthoceras Marcellense, O. Œdipus, Panenka æquilatera, P. Linckloeni, Actinopteria muricata, Styliolina fissurella.*—Oil.
825′		4′ Black bituminous shale.—Fossils abundant. The most noticeable fossil is *Panenka Linckloeni*, which is frequently very large. Other common fossils are *Goniatites uniangularis, Orthoceras subulatum, Styliolina fissurella, Liorhynchus limitaris, Orbiculoidea minuta, Chonetes mucronata, Liopteria lævis, Lunulicardium fragile, L. curtum, Nuculites Nyssa;* fish plates; plants.
829′		22′ Black shales, very bituminous, in which are symmetrical spherical calcareous concretions of from 3″ to 1′ in diameter, which contain beautiful dark crystals, and sometimes a small quantity of oil. Pyrite in nodules and small crystals abundant. The rock seemed to be full of gas, but the amount in the shaft was not sufficient to interfere with the miners. No fossils, except a few plants, observed.

....	......	....
851′		1′ Bluish-black shale with *Orbiculoidea minuta*, very large, abundant. *Goniatites uniangularis*, *Pleurotomaria rugulata*, *Panenka œquilatera*, *Nuculites Nyssa*, and *Liorhynchus limitaris* also occur.
852′		2′ Black, impure limestone, largely composed of *Tentaculites gracilistriatus*. No other fossils.
854′		2′ Blue-black grayish limestone, medium hard. Fossils abundant. *Phacops rana*, *Chonetes lineata*, *Spirifer audaculus*, *Strophodonta inœquistriata*, *S. perplana*, *Athyris spiriferoides*, *Tropidoleptus carinatus*, *Orthothetes pandora*, *Ambocœlia umbonata*, *Modiomorpha subalata*, *Palœoneilo plana*, *Cypricardinia indenta*, *Nuculites oblongatus*, *Tentaculites gracilistriatus*, *Goniatites uniangularis*, *Orthoceras subulatum*, *Pleurotomaria Lucina*, *Streptelasma rectum* and others.
856′		1′ Impure limestone largely made up of *Tentaculites gracilistriatus*. *Goniatites uniangularis*, *Chonetes lineata* and *Liorhynchus limitaris* also occur.
857′		6′ Black shales, not calcareous. *Styliolina fissurella* is very abundant. No other fossils occur. Bituminous concretionary layer 2″ thick, with pyrite.
863′		3′ Black, hard shale with thin calcareous layers every few inches. *Styliolina fissurella* and *Liorhynchus limitaris* make up a large part of the rock. A few specimens of *Panenka Lincklœni* were found.

866′ 4″ Dark gray limestone composed, mainly, of small crinoid stems.

22′ Gray limestone in layers from 4″ to 2′ in thickness, with thin shaly partings, with layers and nodules of chert unevenly distributed. From 866 to 872 and from 880 to 888 the chert was small, while between 872 and 880 it was nearly equal to the limestone. Fossils moderately abundant in the limestone, rare in the chert. The following is a list of the more prominent species.

Phacops pipa, Odontocephalus selenurus, Atrypa reticularis, Cœlospira Camilla, Chonetes lineata, Leptæna rhomboidalis, Ambocœlia umbonata, Strophodonta inæquistriata, S. perplana, Orthothetes Pandora, Orthis lenticularis, Athyris spiriferoides, Spirifer fimbriatus, Sp. duodenarius, Platyceras sp ?.

4″ Light brownish gray layer, very soft, shaly, crumbling quickly on exposure, gypseous though apparently micaceous, with the same fossils abundant in the upper part as occur in the limestone, the rest of the layer non-fossiliferous. In contact, above, is a thin shaly layer of limestone with crinoid stems and many other fossils. The layer rests on a very cherty layer of hard limestone.

887′ 8″

888′		64′ Gray limestone as above, with fossils of the same species, but less abundant. At 945′ many large specimens of *Atrypa reticularis* occur in a thin layer. Chert, varying in color from light blue to black, occurs in nodules, and in layers from ½″ to 4″ thick. Between 888 and 916 there is much chert, from 916 to 930 it decreases in quantity, and from 930 to 952 it was found only in a very few thin seams and small nodules. At 945′ a 3″ layer of very dark limestone contained black chert and considerable pyrite.
....	......	....

954′		24′ Gray limestone, with nearly an equal quantity of chert, which is not in layers, but distributed in nodules and masses irregularly through the bed. This is the most refractory rock encountered in sinking the shaft. Fossils rare. At 975 a few specimens of coral were observed.

....	......	....
978′		20′ 6″ Gray limestone as above, with the chert decreasing slightly in quantity and more regularly distributed — a few layers occurring. From 995 it rapidly diminishes, and at 998′ 6″ disappears. Fossils very rare.
....	......	....

998′ 6″		2′ 6″ gray limestone — no chert. *Phacops bombifrons* very abundant. A few poorly preserved corals, which contain a small quantity of oil observed. Gas.
1001′		5′ Hard, green, and toward the bottom, gray sandstone in which are imbedded pebbles, and quite large rounded fragments of dark and light brown hydraulic limestone; the lines of separation above and below very uneven. Fossils are not abundant. *Atrypa reticularis, Pentamerella arata?* A large species of *Strophodonta. Zaphrentis sp.?* and a few others occur.
1006′		4′ Bituminous dark to light chocolate colored hydraulic limestone, not hard, showing lines of deposition in places. No fossils. Small crystalline masses of calcite and celestite are distributed sparingly through the rock.
1010′		14′ Hydraulic limestone, light colored. Below 1012 showing lines of bedding which divide the rock into thin layers of different shades of brown and gray. Gas and oil were present more abundantly than at any other horizon, the rock appearing to be saturated with oil which exuded in quantities sufficient to cover the surface, and a few ounces of which were collected in the shaft. Fossils of a few species, common. *Spirifer Vanuxemi* very abundant through the rock and in thin layers. *Strophodonta varistriata, Leperditia alta* and *Liopteria rugosa* also occur.

1024′		6′ Very light gray sandstone, clouded with light blue, quite hard. No lines of bedding in upper or lower parts of the bed, but showing laminations, and a wavy, shaly structure in the middle.
1030′		39′ Limestone, varying in color from dark brown to yellowish gray, showing in some of the strata lines of bedding which are sometimes straight, at others irregularly flexed. Small crystalline masses of calcite or celestite are irregularly distributed. Considerable gas and a little oil were found in nearly every stratum. At 1045 a few specimens of *Favosites* were found. No other fossils observed.

....	......	....
1069′		9′ Hard bluish-gray, shaly-looking rock, in layers 1″ to 1′ 6″ thick, separated by thin black seams; shows faint lines of bedding, and changes color but slightly when exposed. At 1075 it is quite shaly. Softer toward the bottom. No fossils.
1078′		9′ Blue-gray, quite hard, shale or marlyte, with nodules, and, toward the bottom, nodular layers, of very light bluish gypsum. From 1082 to 1087 the marlyte and gypsum were in about equal proportion.
....	......	....

1087′		6′ Fine brownish-gray laminated limestone with light blue gypsum abundant in masses and irregular layers 1″ to 4″ thick.
1093′		25′ Limestone, with gypsum in crystals and nodules, but not very abundant. Some parts of the bed have a crystalline appearance, other parts show lines of bedding, straight or distorted. *Leperditia alta* occurs in a few thin layers between 1105 and 1110.

1118′		17′ Dark bluish-gray marlyte, medium hard. Gypsum in crystals and small nodular masses, but not abundant.

1135′		3′ Reddish-brown limestone with dark gypsum in nodular layers.
1138′		45′ Gypsum bed. Dark bluish-gray marlyte, medium hard, with softer, shaly layers. After exposure the rock becomes very light brownish-gray. It contains much gypsum in nodules, and in nodular layers, which are somtimes 1′ or more thick. Lines of deposition are not apparent in the rock when fresh, but exposure produces many shades from brown to nearly white, as the proportion of gypsum varies in the layers, giving the rock a beautifully laminated appearance.

....	......	....
1183′		9′ Light reddish-gray limestone, fine and hard. Gypsum in layers from ½″ to 1′ thick.
1192′		5′ Made up of layers of limestone, marlyte and gypsum.
1197′		1′ Red-gray limestone.
1198′		3′ Bluish-gray marlyte with gypsum in nodular layers.

1201′		2′ Red-gray limestone.
1203′		2′ Bluish-gray marlyte.
1205′		15′ Limestone from very dark to light reddish-gray in color, separated by thin seams of carbonaceous or argillaceous matter into layers of irregular and often uneven thickness from ¼″ to 8″.

1220′		6′ Medium hard bluish marlyte, with some layers brownish. Gypsum in nodules and nodular layers.
1226′		7′ Reddish-brown limestone with black seams, irregularly bedded.
1233′		1′ Bluish-gray marlyte, with nodular layer of gypsum 2″ thick.
1234′		4′ Reddish-gray limestone, in layers 2″ to 4″ thick, very hard. At 1235 in a 6″ layer were found many low pyramidal forms, 1″ to 3″ base, "Hopper-shaped crystals." A few specimens of the same character came from about 1215′.

....	......	....
1238′		2′ Yellowish-gray, irregularly bedded, very hard limestone, separated by black seams into very uneven layers. Gypsum in small crystals.
1240′		1′ Limestone in thin, even layers, not separated, after exposure taking on different shades of reddish-brown to gray, making very handsome rock.
1241′		8′ Limestone, light to dark yellowish-gray, with gypsum in crystals. Separated by black seams into thin layers in which are formed at 1245 low rounded spherical elevations of concretionary appearance 3″ to 6″ in diameter and 1″ to 2″ high. In other layers, much larger, irregularly formed, elevations of similar character occur.
1249′		6′ Red and yellow limestone, with bluish layers 2″ to 12″ thick, containing nodular layers of gypsum 1″ to 6″ thick.

1255′		3′ Yellowish-gray limestone with black seams, irregularly bedded.
1258′		8′ Bluish-gray marlyte with much gypsum in nodules and nodular layers, one at 1262′, 12″ thick, another at 1266′, 6″ thick.
1266′		12′ Yellowish and reddish, very hard limestone, unevenly bedded, with gypsum in seams and thin veins. "Hopper-shaped crystals" at 1274, rare.
....	......	....

1278′		7′ Marlyte, soft bluish-gray. Large proportion of gypsum in nodules and masses.
1285′		2′ Light-brown, medium soft, marlyte, with gypsum abundant in nodules.
1287′		9′ Soft, light-bluish and olive marlyte; no lines of bedding; large proportion of gypsum in masses and nodules. No black seams.

1296′		3′ Hard, fine, brownish-gray limestone, irregularly bedded, many black seams. Gas in small quantity, in the shaft, was ignited and burned for a short time.
1299′		1′ Light-gray, soft limestone. Gypsum in seams.
1300′		11′ Dark-gray, hard, evenly bedded limestone, in layers 5″ to 12″ thick. At 1302–3, many irregularly shaped cavities occur, which appear as though the substance of the rock had decomposed leaving a small quantity of dark brown sediment. The cavities do not occur in this section below 1305.
1311′		3′ Hard, fine, slightly reddish, shaly-looking limestone with straight distinct lines of bedding and gypsum in thin seams.

....	......	....
1314′		2′ Yellow-gray, bituminous, limestone, very hard, sub-crystalline, irregularly bedded, the surface of some layers showing circular or oval elevations 1′ to 2′ in diameter, 6″ high.
1316′		1′ Bluish-gray marlyte. Gypsum in nodules and masses.
1317′		6′ Light-gray, slightly reddish limestone, very fine and hard, in thin layers. An 8″ layer at 1320 contained many "hopper-shaped crystals." Gypsum in thin seams and veins, but not abundant.
1323′		2′ Yellow and light-gray, fine, hard limestone, irregularly bedded, with black seams. Gypsum in veins and seams.
1325′		3′ Limestone, fine, light pinkish-gray to bluish-gray, thinly and evenly bedded.
1328′		3′ Yellow bituminous limestone, unevenly bedded. The walls show a low anticlinal fold, 1′ in height, with an east and west axis, near the middle of the shaft. Thin veins of white gypsum occur.

1331′		6′ Very fine, hard, dark-gray limestone, with faint, even lines of bedding, which become very distinct after exposure, giving the rock a finely laminated appearance. The bed is folded slightly, like the one above.
1337′		2′ Yellowish-gray limestone, irregularly bedded, the layers much flexed and distorted. White crystalline gypsum occurs in many small, thin veins.
1339′		4′ Pinkish-gray limestone, fine and hard, in uneven layers 4″ to 12″ thick. Gypsum in seams and veins.
1343′		11′ Brownish-gray, hard limestone, in layers 3″ to 12″ thick, which are in a broken, disturbed condition, the walls of the shaft showing veins and cracks in every direction. At 1348 the first salt found was observed in a few thin veins, in some of which the vein matter was all salt, in others the wall matter was crystalline gypsum with a thin layer of salt intercalated. Many other veins occurred where only gypsum was found. The color of the salt was pinkish or cream colored; the gypsum was white to pink.
....	......	....

....	......	....
1354′		1′ 6″ Marlyte, bluish gray when fresh, becoming very light gray after short exposure. Salt and gypsum in veins.
1355′ 6″		6″ Nodular layer of gypsum.
1356′		2′ Dark-gray limestone in layers of uneven thickness, containing a large per cent of salt in crystals and nodules. When exposed to rain or placed in water, the rock, by the removal of salt, becomes cellular and friable.
1358′		2′ Bluish-gray shaly marlyte, with many seams and veins of salt, the stratum much broken and disturbed.
1360′		6″ Very thinly laminated limestone, with clear salt in same.
1360′ 6″		8′ 6″ Bluish-gray shaly marlyte, which, after short exposure, becomes a light, creamy gray, with many cracks and displacements of the strata, the interstices being filled with white and pinkish crystalline salt. Considerable gypsum also occurs. The rock is more broken toward the bottom of the bed, and the proportion of salt is greater. 1369′ 8″
1370′		At 1369, at the south end of the shaft, a bed of nearly pure, coarsely crystalline salt was reached, which on the east wall of the shaft, showed a dip of 18° on the upper line of contact, and 4° 8″ on the lower toward the north, the layer being 8″ thick at the south end and 3′ at the northeast corner. A small proportion of shale is mixed with the salt.

1370′		Marlyte, with pink, cream-colored and white salt in veins and seams. Gypsum present, not abundantly.
1374′		Transparent salt in large fine crystals. Slight proportion of marlyte in thin flakes. Traces of sedimentation destroyed.
1377′		1′ 6″ Bluish marlyte, becoming light gray on exposure, much broken; little salt. Gypsum abundant.
1378′ 6″		11 "Mixed" salt, coarsely crystalline; no traces of sedimentation apparent. Marlyte in flakes and small fragments is present all through the bed, more abundantly in some parts than others. At 1384 a seam of marlyte 1″ thick extends across the shaft, dipping irregularly toward the north 2′ in the length of the shaft.

1390′		Between 1388 and 1390, with an irregular but quite distinct line of separation from the mixed salt above, the bed becomes nearly homogenous, and shows in clear, bluish, almost transparent, or whiter, more opaque layers of salt in straight bands on the walls of the shaft, abundant evidences of deposition. The salt crystals are somewhat finer than in the mixed salt above. There appears to be very little impurity of any kind in the salt.
1403′		3′ 6″ Dark gray, hard limestone, in layers 4″ to 8″ thick, containing much salt in veins and seams and in crystals 1 mm. to 2 mm. in diameter, which dissolve when the rock is immersed in water, leaving it cellular and friable.

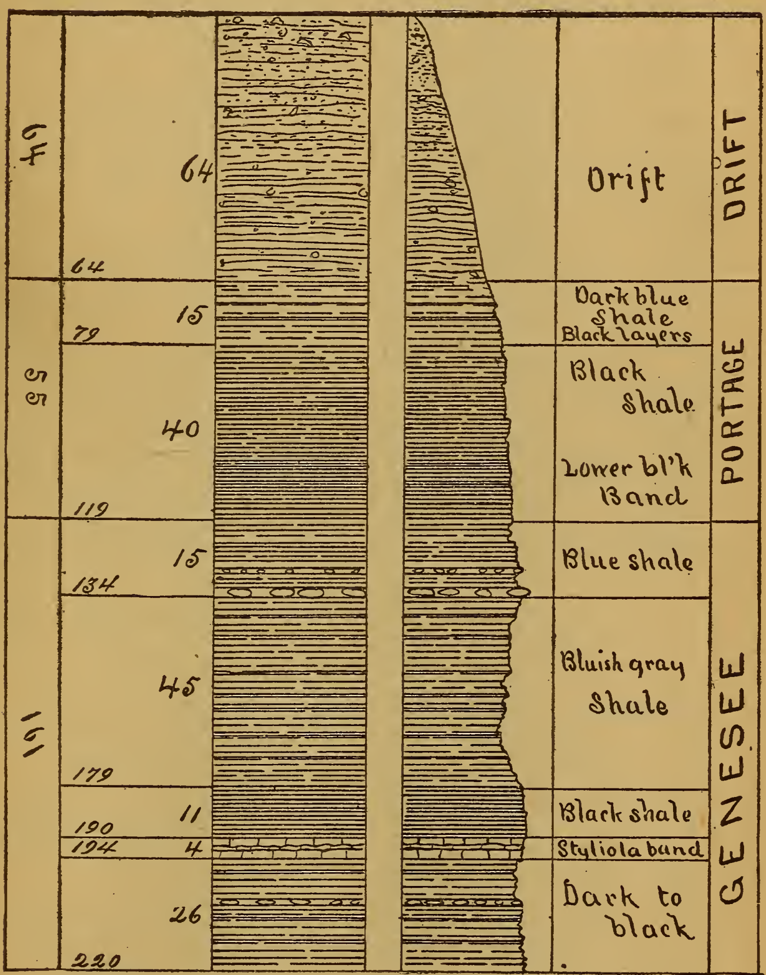
1406′ 6″		2′ 6″ Soft gray limestone, laminated and shaly. Pinkish salt in veins and seams.
1409′		1′ 6″ Very soft, bluish marlyte, with a layer ½″ thick of green marlyte. Pink and white salt in seams and veins.
1410′ 6″		15′ 6″ White and pink salt in large crystals, with fragments and flakes of marlyte occurring in varying proportions, making a sort of breccia, the upper and lower parts of the bed being clearer than the middle. From 1424 to 1426 the intermingled rock is dark gray limestone.
....	......	....

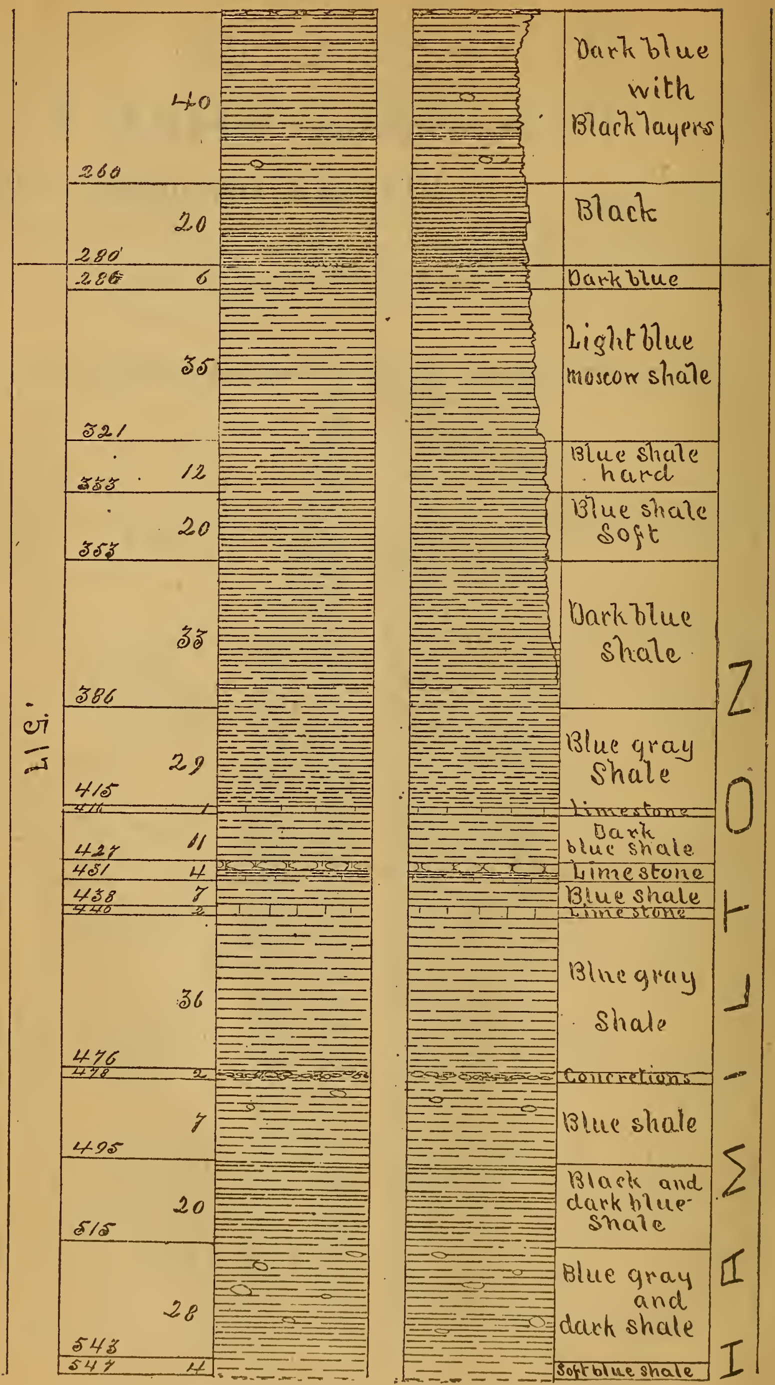
....	......	....
1426′		2′ Dark gray, hard limestone, showing lines of deposition; the strata but slightly disturbed.
1428′		4′ Green marlyte, very soft, with red and pink salt in veins and thin layers, also some small crystals of pyrite. At 1430 and 1431 layers of pink salt 3″ thick occur.
1432′		

BOTTOM OF SHAFT.

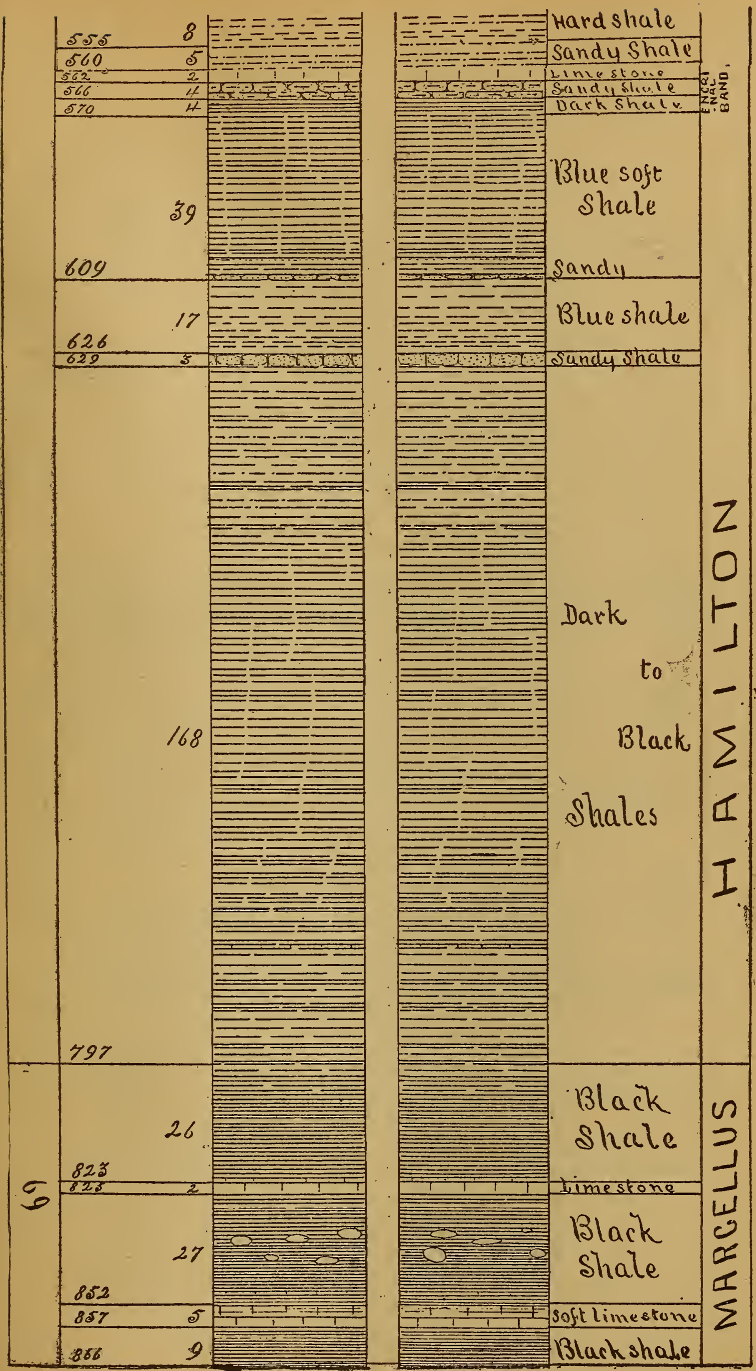
The rock section in the LIVONIA SALT SHAFT

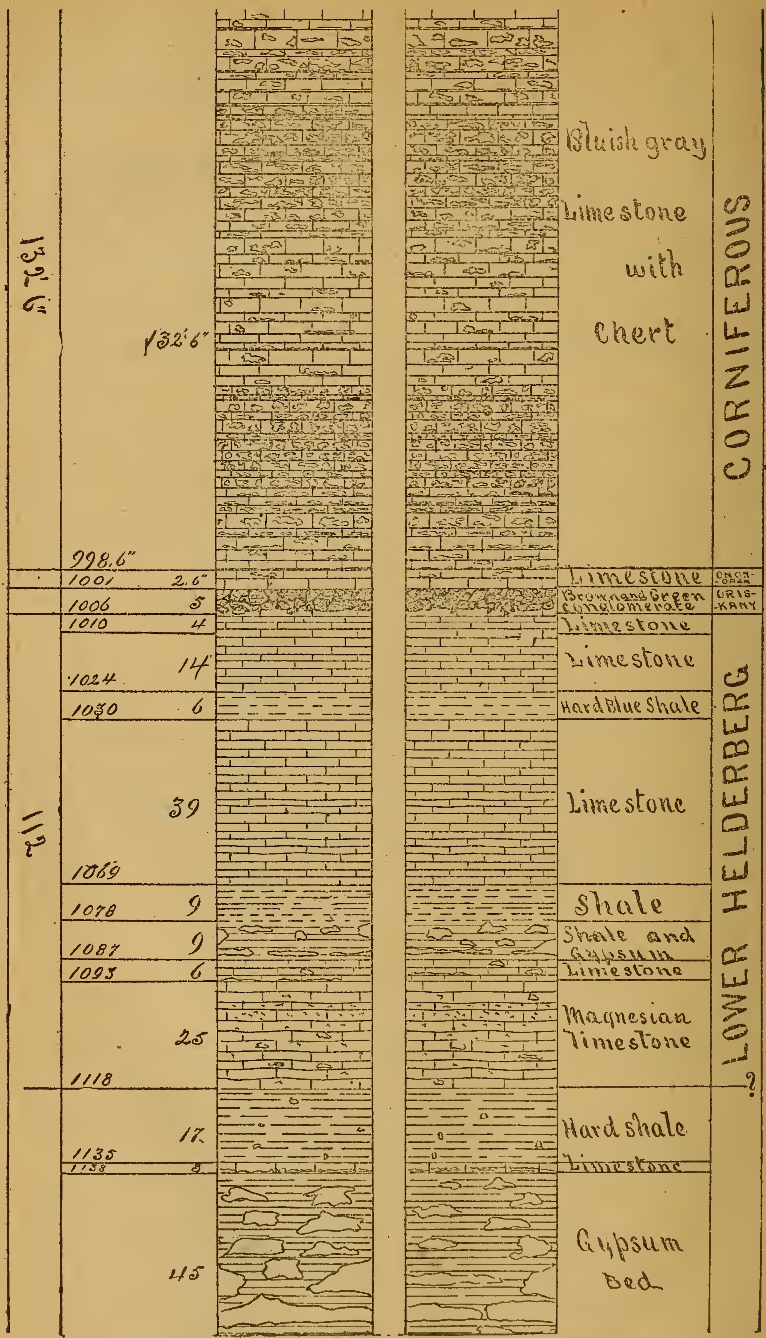
By D. D. Luther. Livonia, Livingston Co. N.Y.

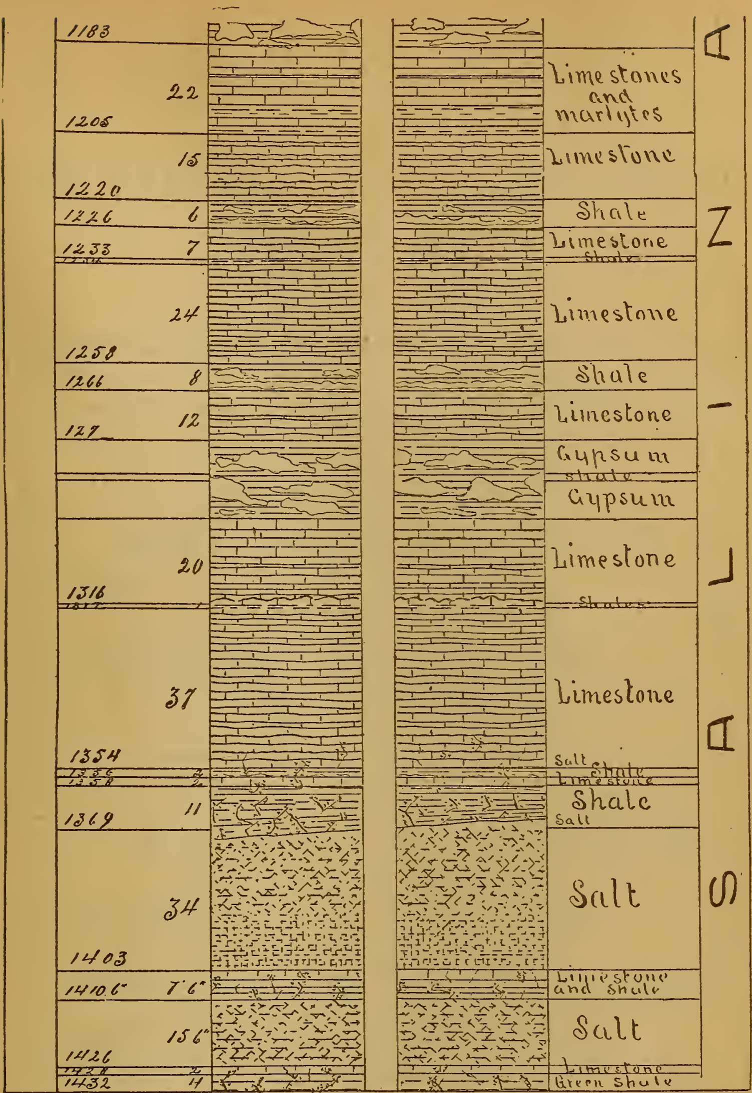




517
40
260
Dark blue with Black layers
20
280
Black
286
6
Dark blue
35
321
Light blue moscow shale
12
333
Blue shale hard
20
353
Blue shale Soft
33
386
Dark blue shale
29
415
Blue gray Shale
1
Limestone
427
11
Dark blue shale
431
4
Limestone
438
7
Blue shale
440
2
Limestone
36
476
Blue gray Shale
478
2
Concretions
7
495
Blue shale
20
515
Black and dark blue Shale
28
543
Blue gray and dark shale
547
4
Soft blue shale
HAMILTON


555 8 Hard shale
560 5 Sandy Shale
562 2 Limestone
566 4 Sandy Shale
570 4 Dark Shale
ENCRI-NAL BAND.
39 Blue soft Shale
609 Sandy
17 Blue shale
626
629 3 Sandy Shale
168 Dark to Black Shales
HAMILTON
797
26 Black Shale
823
825 2 Limestone
27 Black Shale
852
857 5 Soft limestone
866 9 Black shale
MARCELLUS
69

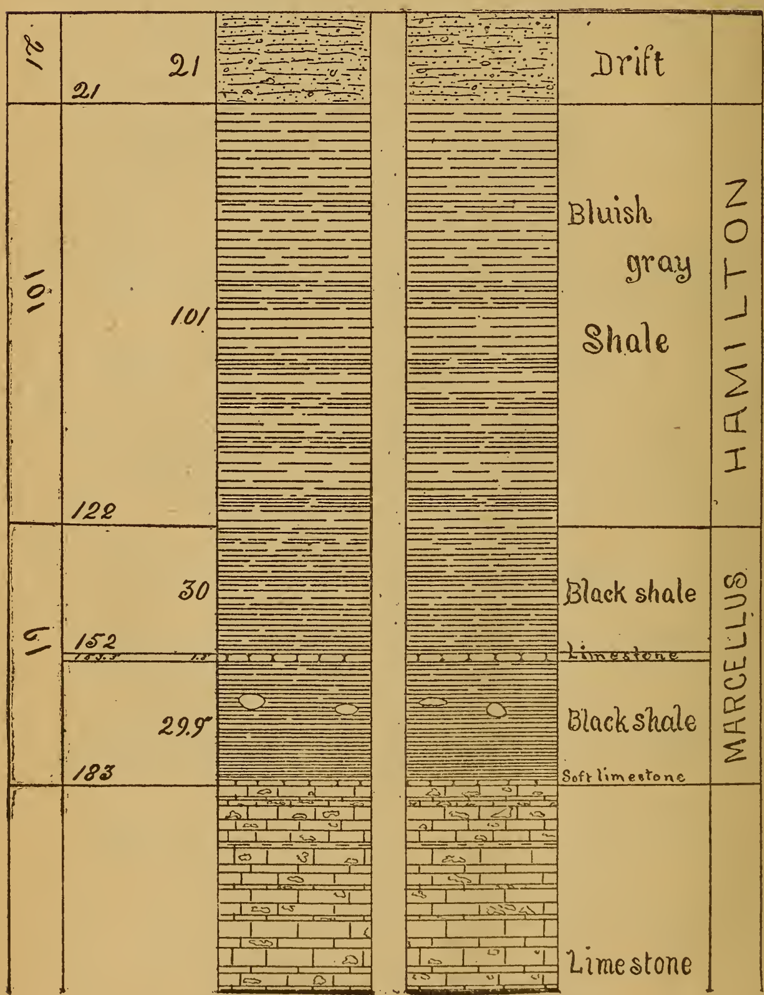

132' 6"
112
132' 6"
998.6"
1001 2.6"
1006 5
1010 4
1024 14
1030 6
39
1069
1078 9
1087 9
1093 6
25
1118
1135 17
1138 3
45
Bluish gray Limestone with Chert
Limestone
Brown and Green Conglomerate
Limestone
Limestone
Hard Blue Shale
Limestone
Shale
Shale and Gypsum
Limestone
Magnesian Limestone
Hard shale
Limestone
Gypsum Bed
CORNIFEROUS
ORIS-KANY
LOWER HELDERBERG
?

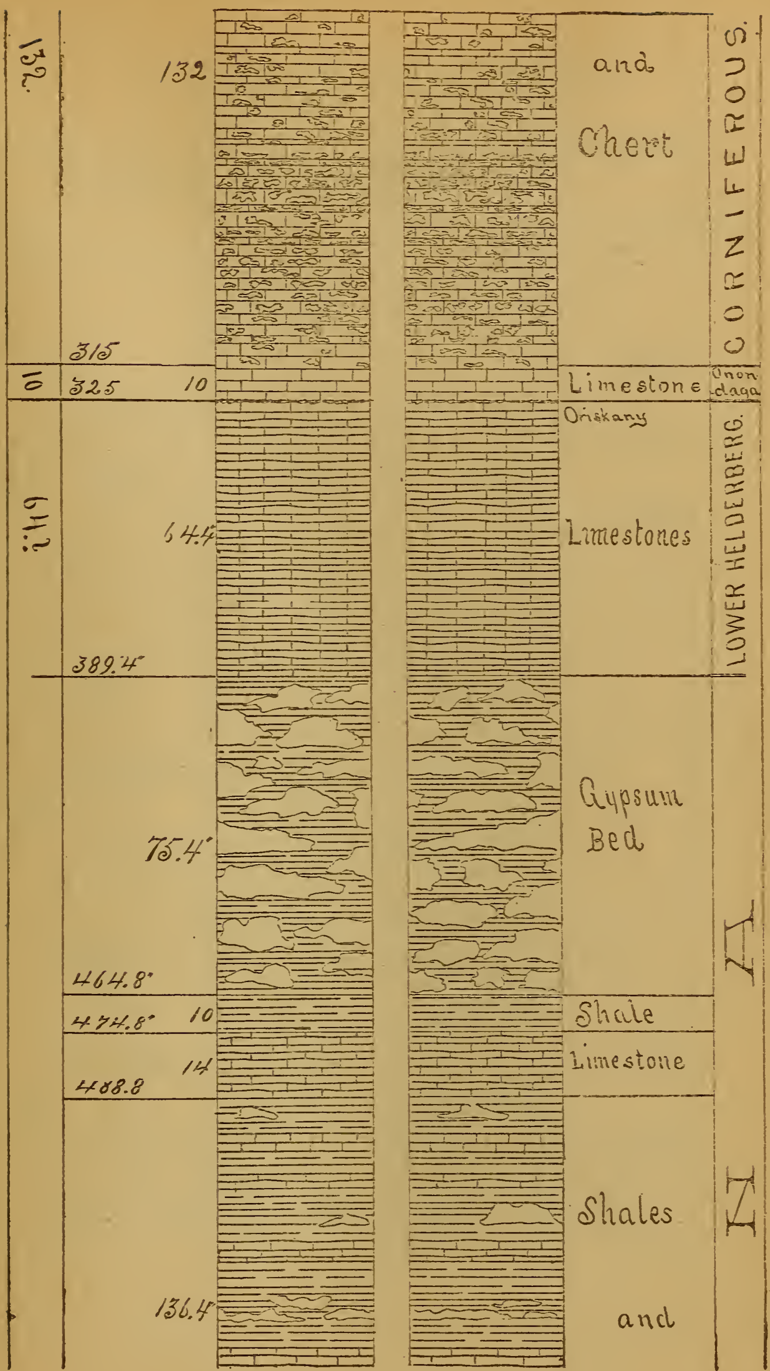

1183
22
1205
Limestones and marlytes
15
1220
Limestone
1226 6
Shale
1233 7
Limestone
Shale
24
1258
Limestone
1266 8
Shale
12
Limestone
Gypsum
Shale
Gypsum
20
1316
Limestone
Shale
37
1354
Limestone
Salt
Shale
Limestone
11
1369
Shale
Salt
34
1403
Salt
1410.6" 7'6"
Limestone and Shale
15'6"
1426
Salt
Limestone
1432 4
Green Shale
SALINA

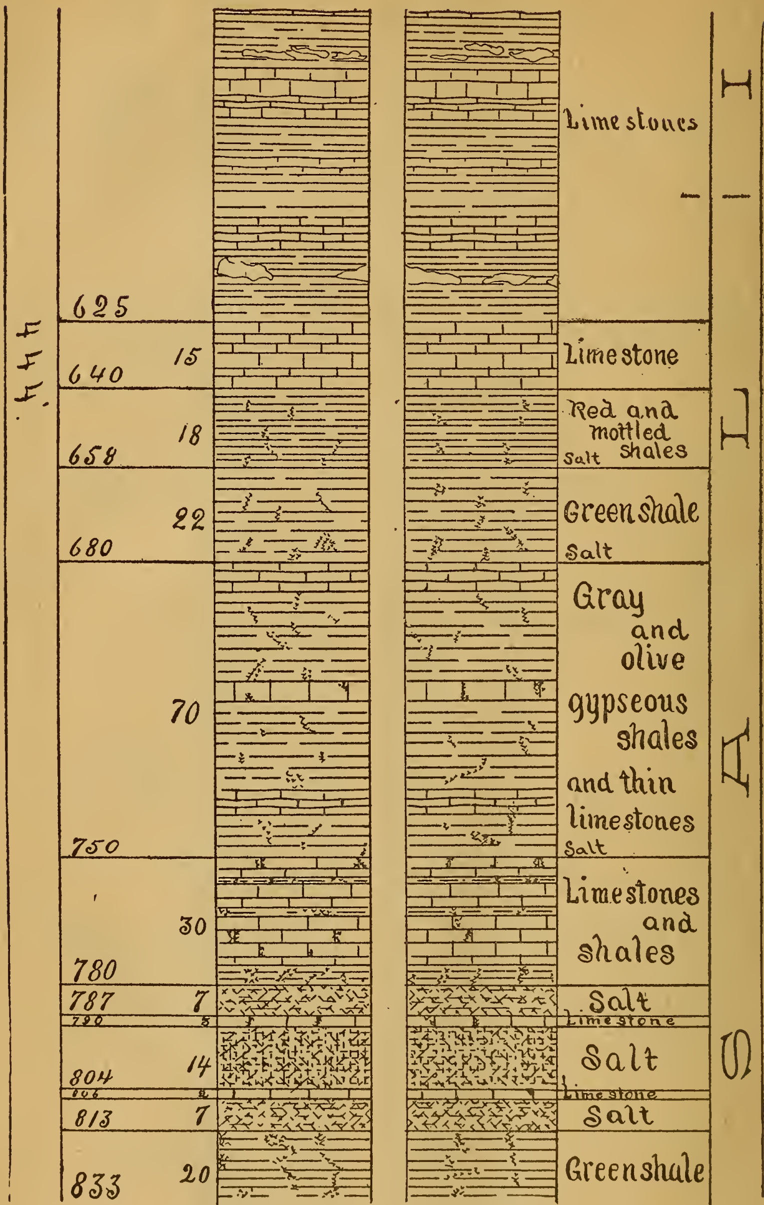
39

The rock section in the LEHIGH SALT SHAFT

By D. D. Luther. Le Roy. N.Y.

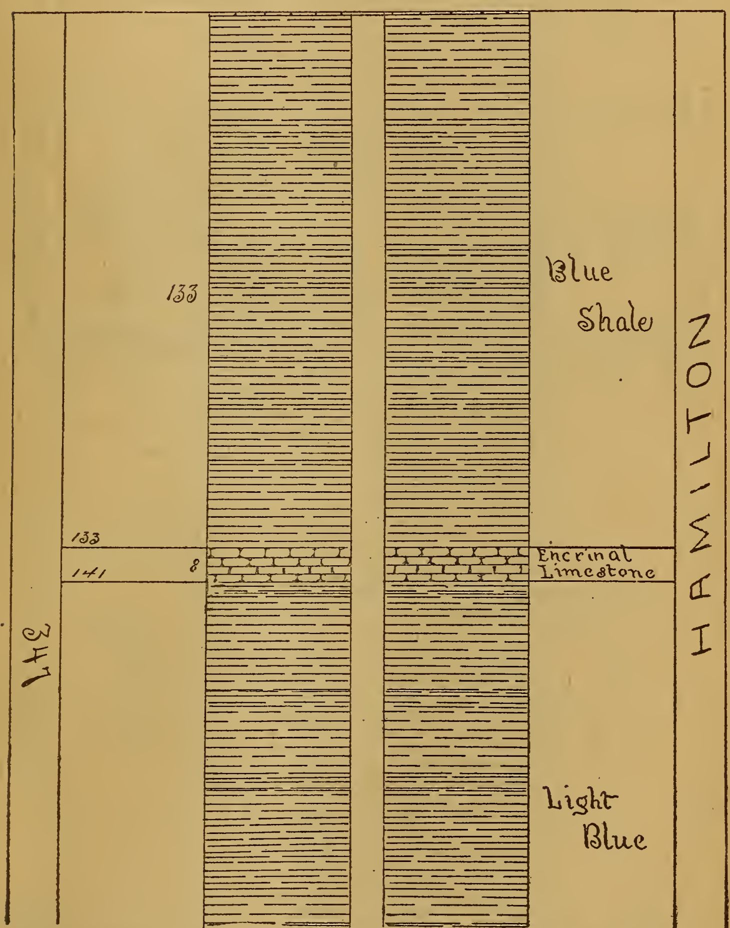


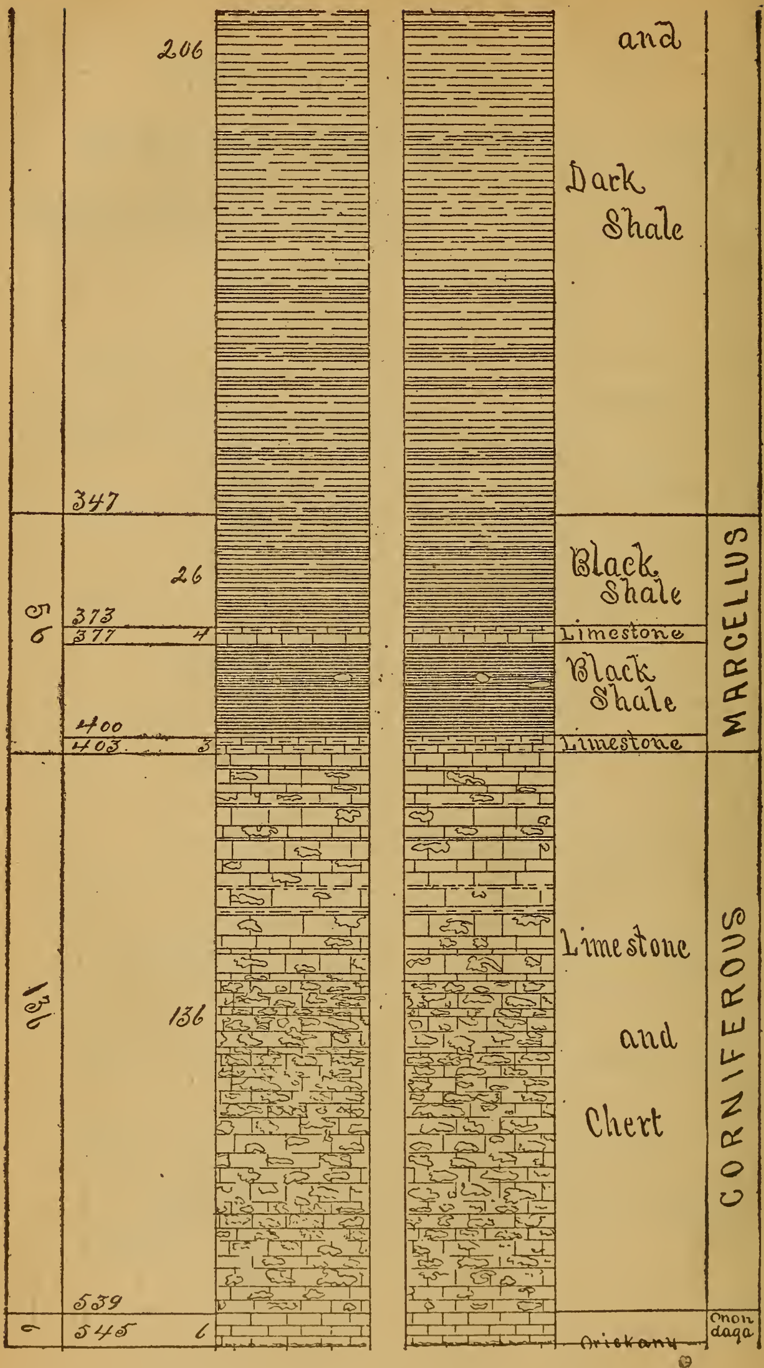

132
132
and
Chert
CORNIFEROUS.
315
10
325
10
Limestone
Onon-
daga
Oriskany
64.4
Limestones
LOWER HELDERBERG.
389.4'
Gypsum
Bed
75.4'
464.8'
474.8'
10
Shale
14
Limestone
488.8
Shales
136.4
and

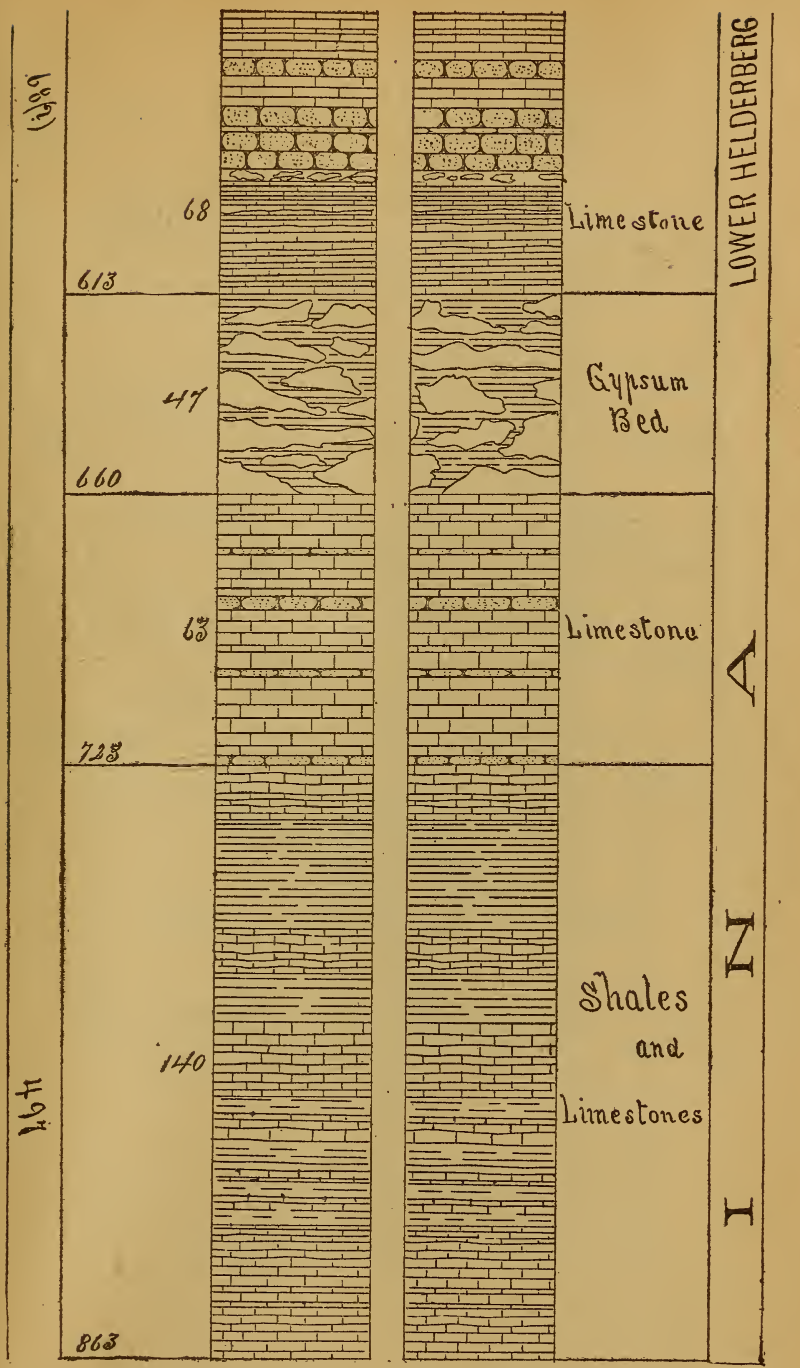

Lime stones
625
15
640
Limestone
18
658
Red and mottled shales
Salt
22
680
Green shale
Salt
70
750
Gray and olive gypseous shales and thin limestones
Salt
30
780
Limestones and shales
787
7
Salt
Limestone
804
14
Salt
Limestone
813
7
Salt
833
20
Greenshale

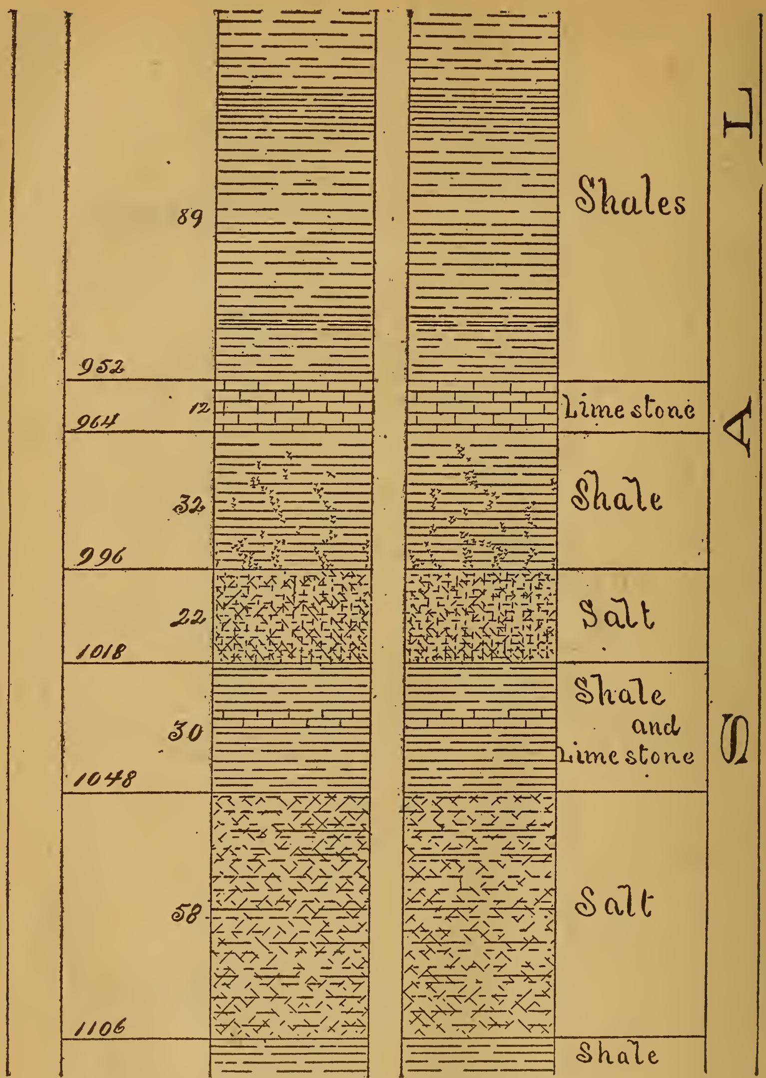
The rock section in the RETSOF SALT SHAFT

By D. D. Luther — York. Livingston Co. N.Y.




206
and
Dark
Shale
347
Black
Shale
26
56
373
377
4
Limestone
Black
Shale
400
403
3
Limestone
MARCELLUS
136
136
Limestone
and
Chert
CORNIFEROUS
539
6
545
6
Onondaga
Oriskany

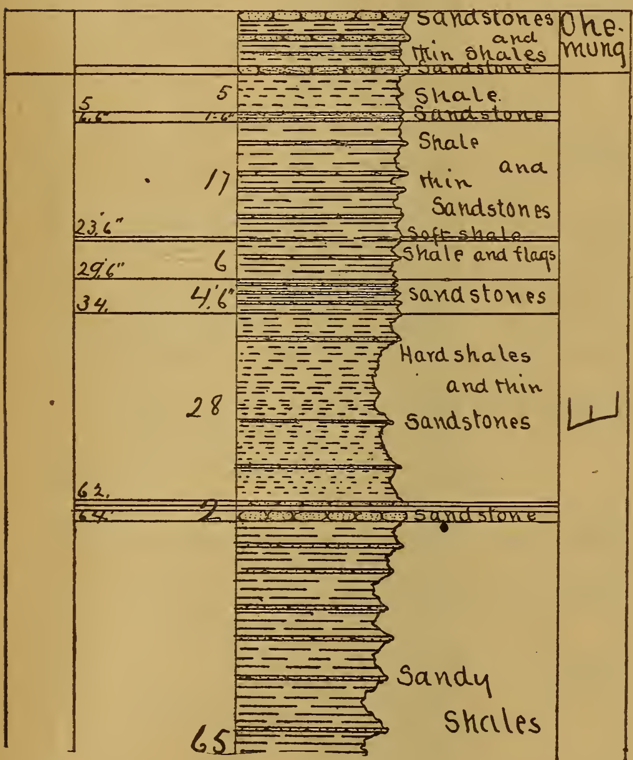

(1589)
68
613
Limestone
LOWER HELDERBERG
47
Gypsum Bed
660
63
Limestone
723
140
Shales and Limestones
863
1471
NIAGARA


89
952
12
964
32
996
22
1018
30
1048
58
1106
Shales
Limestone
Shale
Salt
Shale and Limestone
Salt
Shale

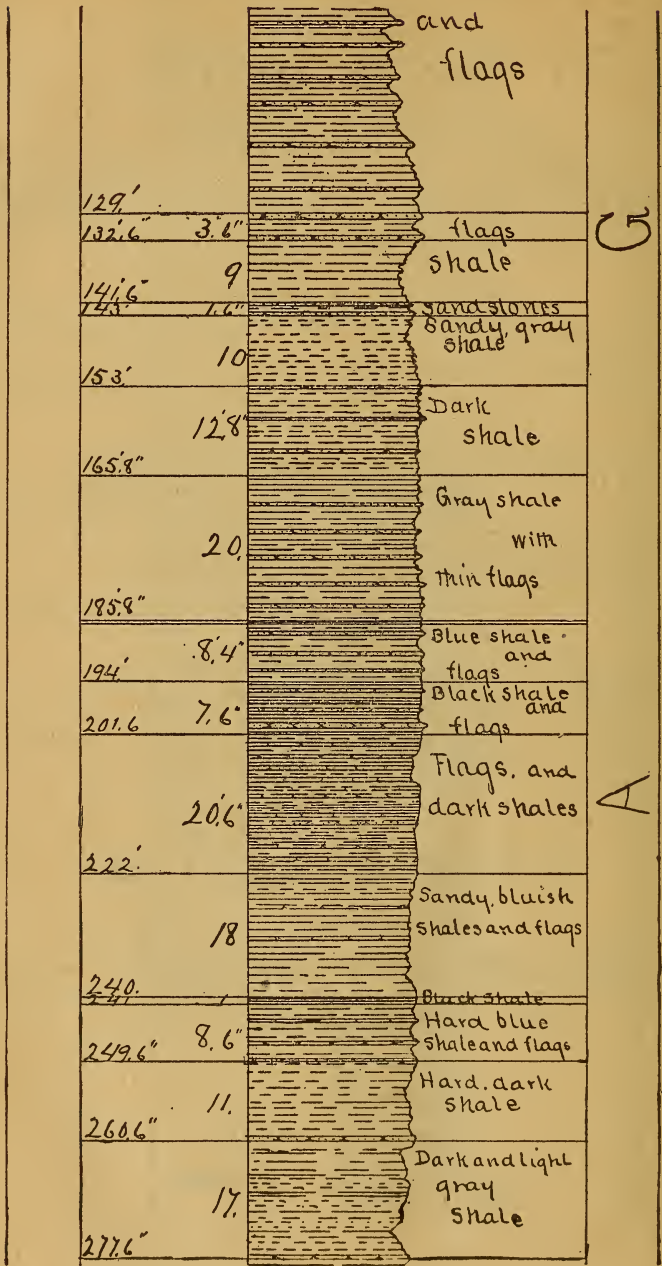
The Portage Section at Naples, N.Y.

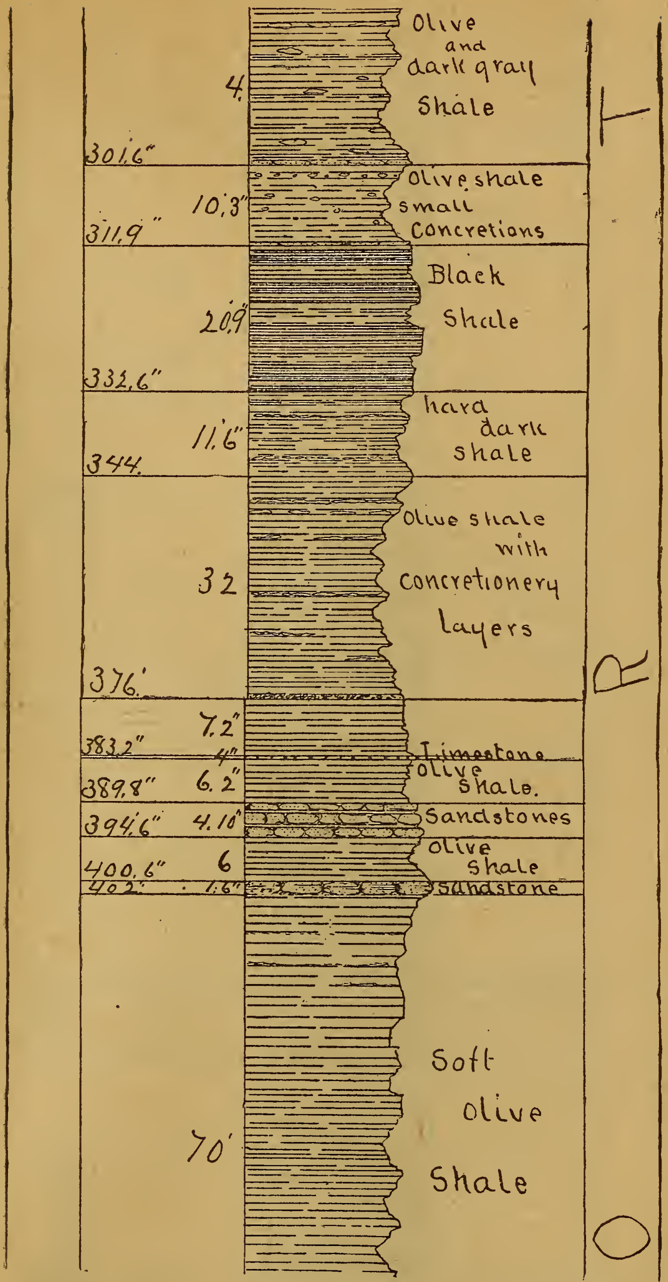
From the layer containing Chemung fossils at the 3d falls in the Grimes gully to the bottom of the "transition shales" in Snyders gully, Woodville

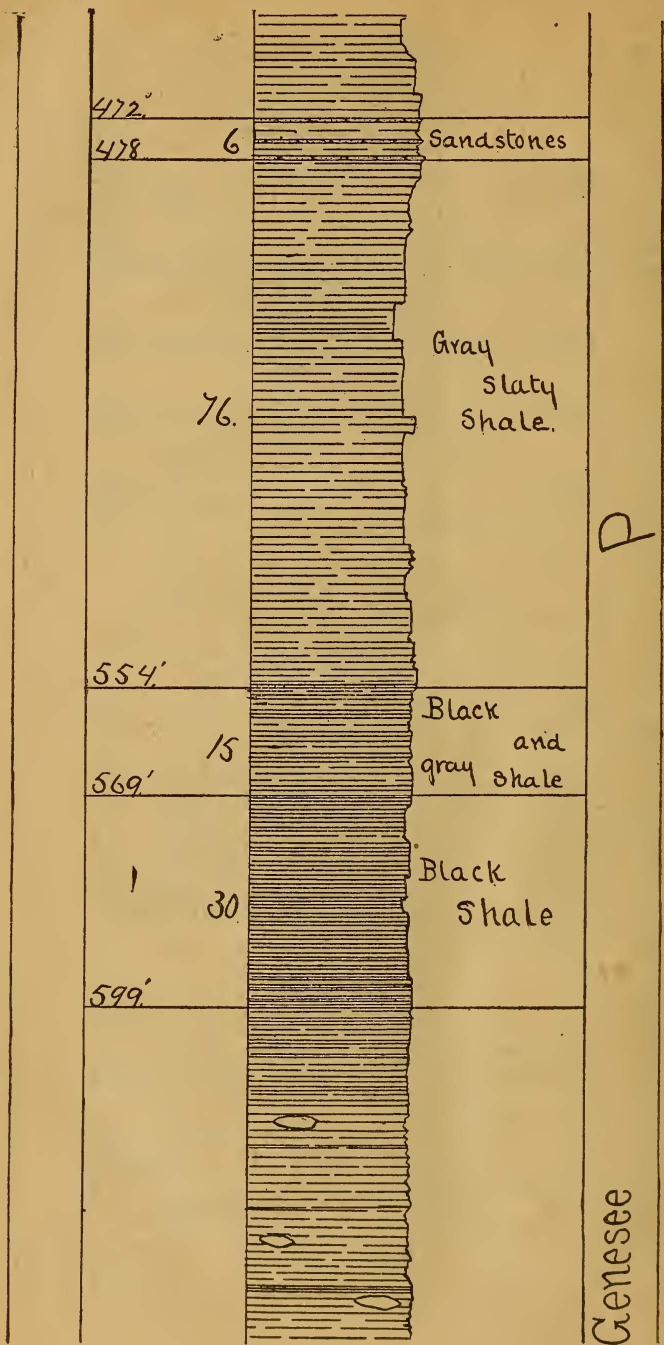
By D. D. Luther



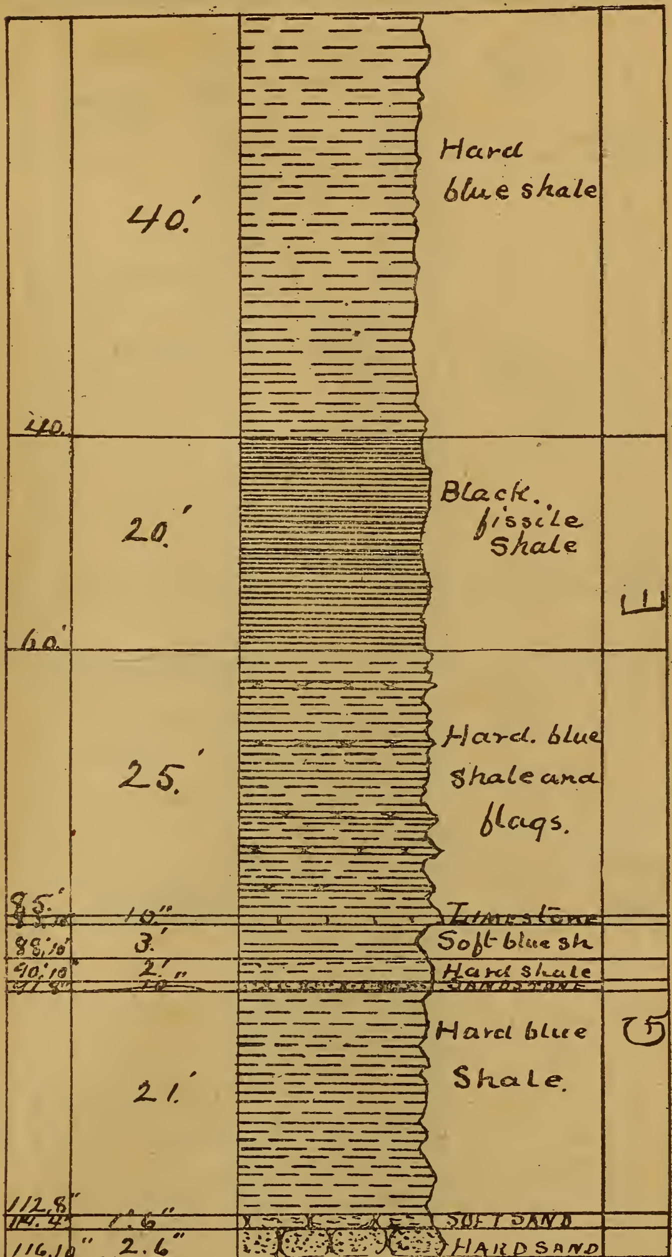
40

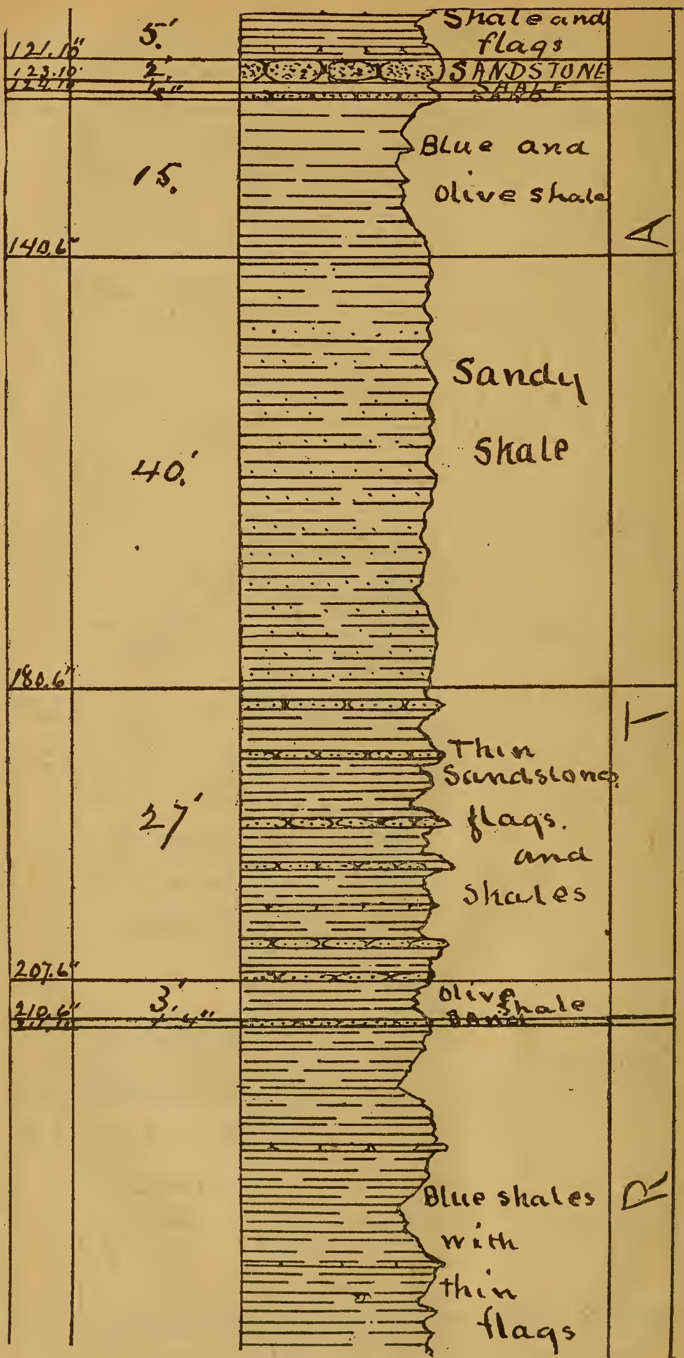

and flags
129'
132'.6"
3'.6"
flags
9
shale
141'.6"
143'
1'.6"
sandstones
10
Sandy, gray shale
153'
12'.8"
Dark shale
165'.8"
20
Gray shale with thin flags
185'.8"
8'.4"
Blue shale and flags
194'
7'.6"
Black shale and flags
201.6
20'.6"
Flags, and dark shales
222'
18
Sandy bluish shales and flags
240.
Black shale
8'.6"
Hard blue shale and flags
249'.6"
11.
Hard, dark shale
260'.6"
17.
Dark and light gray shale
277'.6"

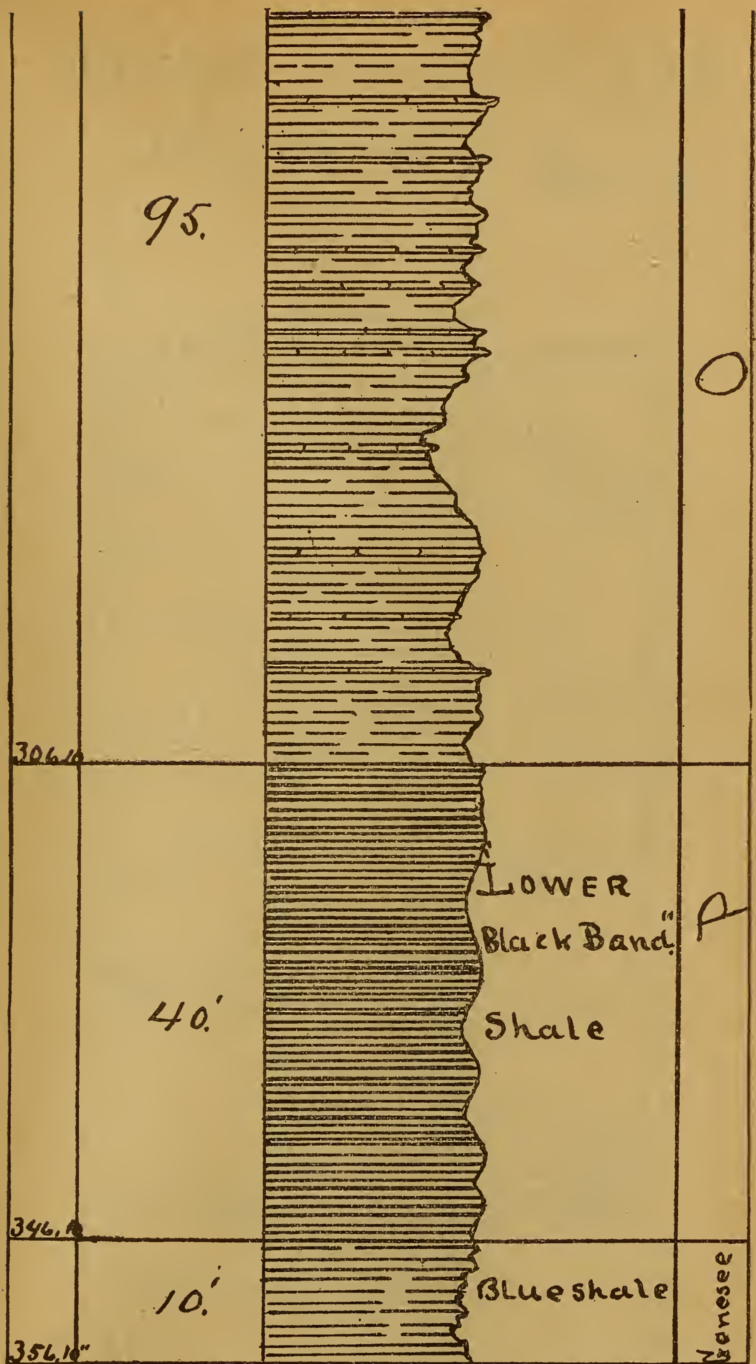

Olive and dark gray Shale
4.
301.6"
Olive shale small Concretions
10.3"
311.9"
Black Shale
20.9"
332.6"
hard dark shale
11.6"
344.
Olive shale with concretionery layers
32
376'.
7.2"
383.2"
Limestone
4"
olive shale.
389.8"
6.2"
Sandstones
394.6"
4.10"
olive shale
400.6"
6
Sandstone
402'
1.6"
Soft olive Shale
70'

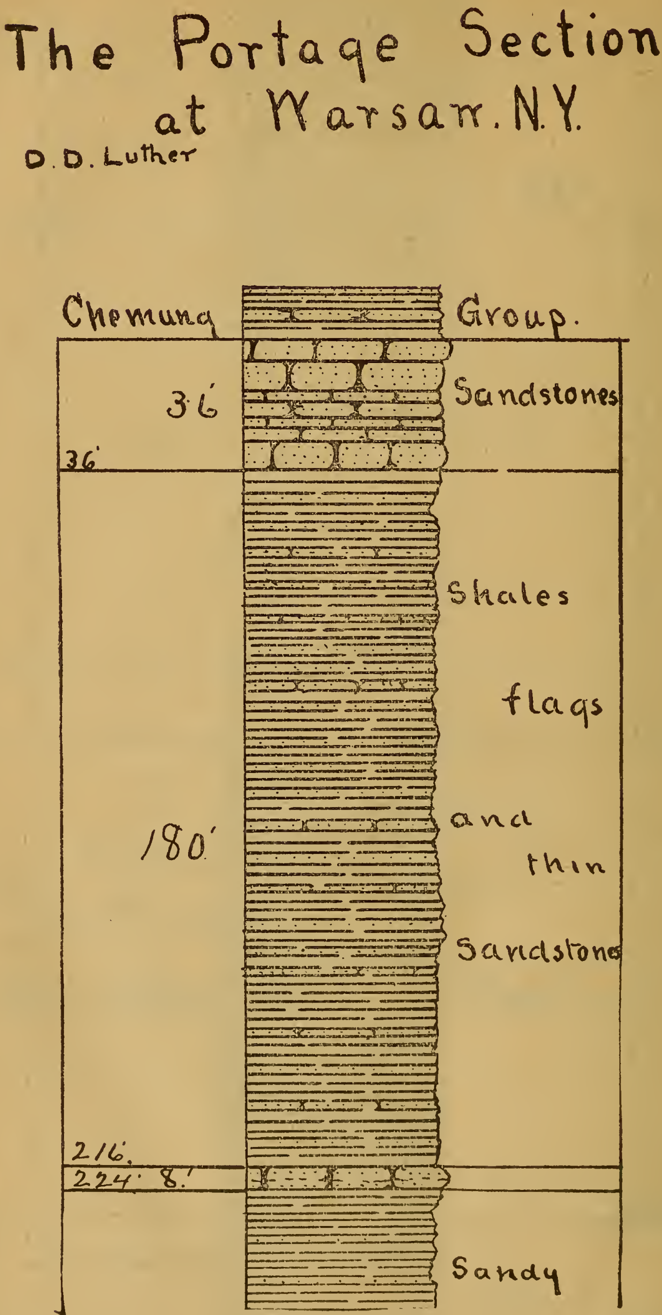

472'
478
6
Sandstones
76.
Gray slaty Shale.
554'
15
Black and gray shale
569'
30
Black Shale
599'
P
Genesee

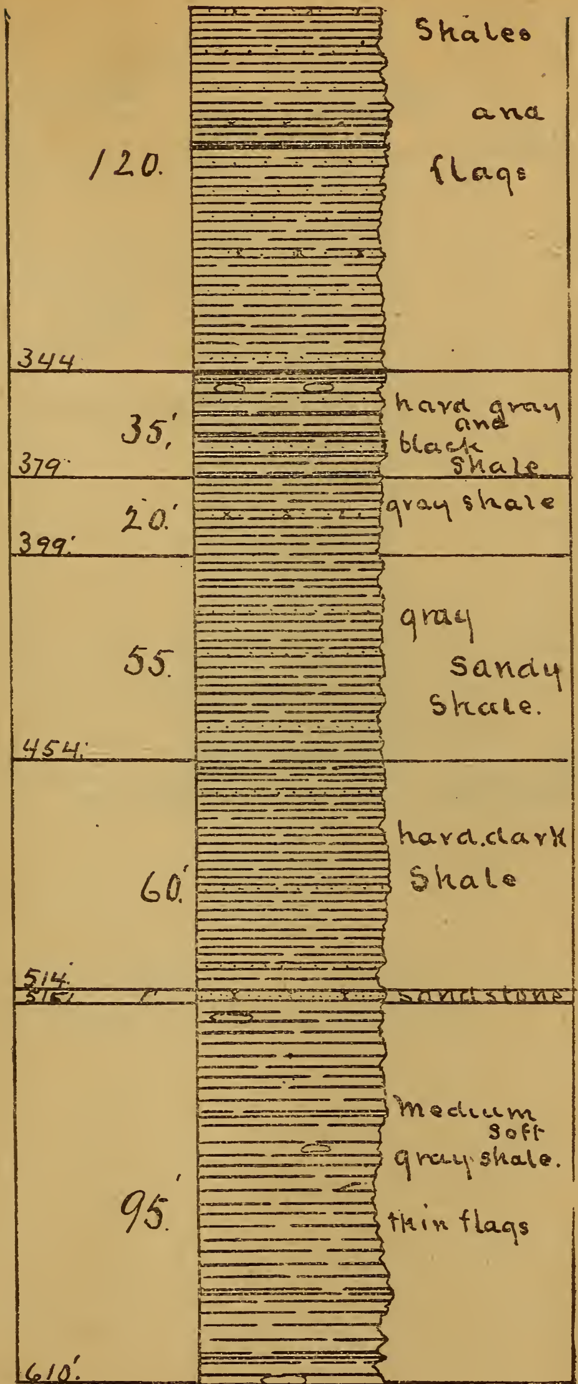
Lower Portage Section in Belknap's gully, near Branchport, Yates co. D.D.L.

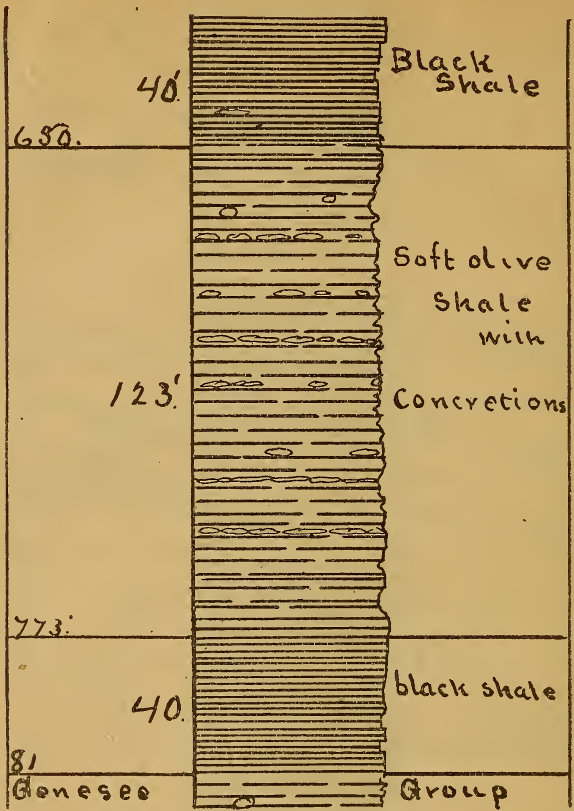


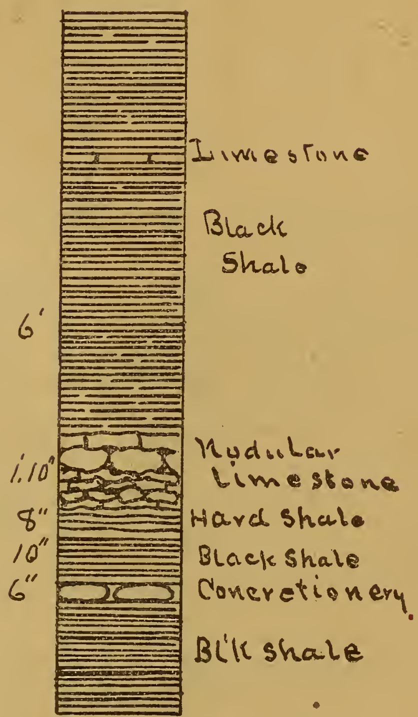

121.10"
5'
Shale and flags
123.10"
2'
SANDSTONE
SHALE
15'
Blue and olive shale
140.6"
40'
Sandy Shale
180.6"
27'
Thin Sandstone flags and shales
207.6"
3'
Olive shale
210.6"
Blue shales with thin flags


95.
O
306.10
LOWER
Black Band"
Shale
40.'
A
346.10
Blueshale
10.'
356.10"
Genesee

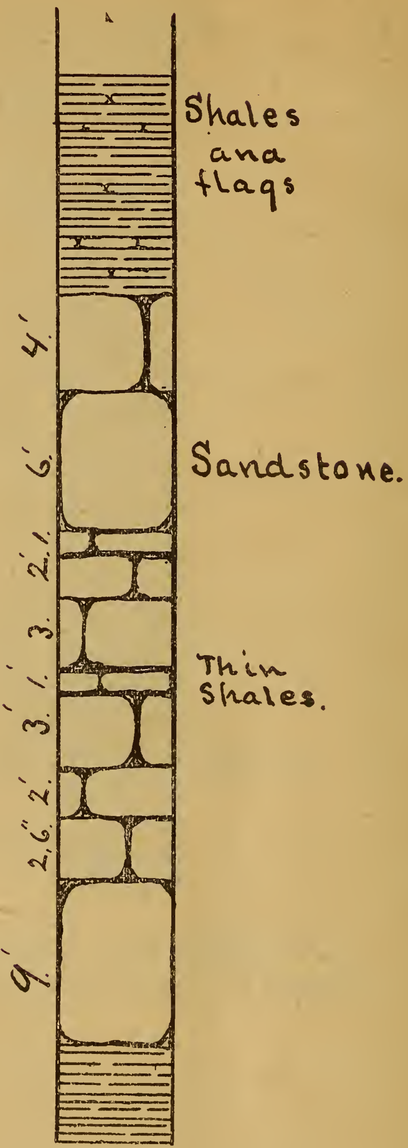

The Portage Section
at Warsaw. N.Y.
D. D. Luther
Chemung Group.
36'
36'
Sandstones
Shales
flags
and
thin
Sandstone
180'
216'.
224'. 8.'
Sandy


Shales and flags
120.
344
35'
hard gray and black shale
379
20'
gray shale
399'
55.
gray sandy shale.
454'
60'
hard dark shale
514'
sandstone
95'
Medium soft gray shale.
thin flags
610'


Black Shale
40'
650.
Soft olive Shale with Concretions
123'
773.
black shale
40.
81
Genesee Group



The Styliola Band
Eagle Pt. Conesus Lake.



The Portage Sandstones
at Rock Glen. N.Y.

The Succession of the Fossil Faunas in the Section of the Livonia Salt Shaft.

By John M. Clarke.

The Succession of the Fossil Faunas in the Section of the Livonia Salt Shaft.

Although the detailed section, which has been given by Mr. Luther in the preceding pages, affords a fund of information as to the succession of the faunas, it has seemed desirable, even at the risk of partial repetition, to bring together under one head all the knowledge obtained which bears upon the appearance, predominance and disappearance of organic types. From the outset of the work it was the purpose to record the exact horizon of every recognizable species obtained, and this has been done in every instance in which there has been no doubt as to such points. As elsewhere explained, each specimen received the mark of its horizon as it was taken out, and the fossils were collected, not alone with the purpose of securing excellence in preservation, but of obtaining, as far as circumstances permitted, a full representation of the organic life in the rocks excavated. The careful method of blasting in benches and the precise measurements made by Mr. Luther have reduced the error in these determinations to its lowest terms. Care has been taken to make this record of faunas as complete as possible, the more so in view of the fact that no such section affording an uninterrupted sequence through so many feet of palæozoic strata, with such unrestricted opportunity to study the fossils of these strata, has ever before been afforded.

It is a most regrettable circumstance that the first 384 feet of this remarkable section was lost from influences beyond control, and this has lost to us, for the present at least, a complete section of the Genesee shales and the upper and most highly fossiliferous beds in the Hamilton group.

Mr. Luther has succeeded in restoring the geological section by careful study of outcrops in the vicinity of the shaft, but we have no more precise knowledge of the missing faunas than such as it has been possible to ascertain from an examination of the material collected from the *dump* already accumulated at the time the systematic operations were begun. This has afforded but little evidence in regard to the fauna of the Portage and Genesee shales, which were the rocks first to be excavated, and, therefore, the most deeply buried under the succeeding debris.

The upper shales of the Hamilton group, to the beginning of the recorded section, have furnished many fossils, and these are here registered as a preliminary to the detailed section.

Fauna of the Hamilton shales from the base of the Genesee shales, at 225 feet to a depth of 385 feet. Rocks soft, compact, bluish shale, crumbling rapidly on exposure, with occasional thin calcareous layers.*

Abundant and characteristic.

Phacops rana,
Cryphæus Boothi,
Homalonotus De Kayi,
Glyptodesma erectum,
Ambocœlia umbonata,
Lingula punctata.

Common.

Diaphorostoma lineatum,
Aviculopecten princeps,
A. scabridus,
Actinopteria decussata,
Grammysia arcuata,
Spirifer mucronatus,
S. audaculus,
Chonetes scitula,
Dignomia alveata,
Streptelasma rectum,
Pleurodictyum stylopora,
Polypora multiplex,
Stictopora incisurata.

Occasional.

Proetus macrocephalus,
Orthoceras nuntium,
Tentaculites bellulus,
Styliolina fissurella,
Platyceras subrectum,
P. symmetricum,

Occasional — (Continued).

Aviculopecten exacutus,
Pterinopecten undosus,
Lyriopecten orbiculatus,
Grammysia alveata,
G. bisulcata,
Palæoneilo tenuistriata,
P. fecunda,
P. plana,
Stropheodonta junia,
S. inæquistriata,
Orthothetes arctostriata,
Productella spinulicosta,
Spirifer Marcyi,
Atrypa spinosa,
Liorhynchus quadricostata,
Modiomorpha concentrica,
Goniophora angulata,
Cypricardinia indenta,
Tellinopsis subemarginata,
Orthonota undulata,
O. parvula,
Microdon tenuistriatus,
Prothyris lanceolatus,
Atrypa reticularis,
Athyris spiriferoides,
Spirifer sculptilis,
Tropidoleptus carinatus,
Stropheodonta perplana,

* This list was communicated by the writer at page 326 of the Report of the State Geologist or 1891 (published 1893).

Occasional—(Continued).
Pholidops Hamiltoniæ,
Orbiculoidea media,
Lingula Delia,
L. maida
L. ligea,
L. densa,
Fenestella sp.?
Glauconome carinata,
Heliophyllum Halli,
Amplexus intermittens.

Rare.
Bellerophon Leda,
Aviculopecten ornatus,
Modiomorpha macilenta,
M. concentrica,
Lunulicardium? lineolatum,
Ambocœlia spinosa,
Cryptonella planirostra,
Terebratula Ontario,
Stropheodonta concava,
Chonetes coronata,
Orthis Vanuxemi,

Rare—(Continued).
Orbiculoidea humilis,
O. grandis,
Goniatites uniangularis,
Leptodesma Rogersi,
Spirifer granulifer,
Pentamerella Pavilionensis,
Favosites Argus,
Reptaria stolonifera,
Chaetetes fruticosus,
Dictyonema Hamiltoniæ,
Platycrinus sp.?

The included thin calcareous bands contain:

Proetus macrocephalus,
Platyceras symmetricum,
Actinopteria decussata,
Spirifer fimbriatus,
S. granulifer,
S. audaculus,
Lichenalia vesciculata,
Stictopora incisurata.

380–385	*Beginning of recorded section.* Shales as above.
	Thin limestone with fragments of crinoids and bryozoa.
386	Compact, heavy-bedded, blue-black shales with greasy feel when fresh, breaking across the lines of sedimentation. On weathering it becomes blue-gray and crumbles rapidly to fine, irregular, trihedral or columnar pieces. The fossils are scattered uniformly throughout the mass and do not occur in distinct horizons. Of the TRILOBITES, *Cryphæus Boothi* is very abundant, *Homalonotus DeKayi* is on the decrease and *Phacops rana* is quite rare, especially toward the lower part of the shales. CEPHALOPODS: *Orthoceras emaceratum* abundant; *Gyroceras liratum* occasionally; a *Nautilus*, probably *N. Hyatti* and *Goniatites uniangularis*. GASTROPODS: Rare, with the exception of *Platyceras subrectum*. Other species observed are *Platyceras bucculentum*, *Diaphorostoma lineatum*, *Pleurotomaria capillaria*, *P. trilix*, *P. rugulata*, *Bellerophon Leda*, *B. patulus*. LAMELLIBRANCHS: *Actinopteria decussata* predominant; *Glyptodesma erectum* very common. Other species are *Liopteria Conradi*, *Nucula bellistriata*, *Tellinopsis subemarginata* and *Pterinopecten undosus*. BRACHIOPODS: The horizon is marked by the great abundance of species of *Lingula*, occurring for the most part below 400 ft., viz.: *L. sp.?* (like *densa*), *L. punctata*, *Dignomia alveata*, *L.* cf. *complanata* and two additional species probably new. Of other brachiopods *Spirifer audaculus*, *S. fimbriatus* and *Orthothetes arctostriata* are common. *Tropidoleptus carinatus* very abundant. Other species, with exception of *Chonetes scitula*, *C. deflecta*, *C. lepida* and *Spirifer mucronatus*, are not frequent. BRYOZOA: Fenestelloids rare; *Taeniopora exigua*, *Stictopora incisurata*, *Hederella Canadensis* not uncommon. CORALS: *Pleurodictyum stylopora*; no other favositoids; no cyathophylloids.

....	....
415	Hard gray limestone. Few fossils of common species and poorly preserved.
416	Hard, more calcareous blue shales with irregularly distributed thin layers and lenticular masses of limestone made up of corals and comminuted crinoids. The fauna recorded is essentially that of the shales, as the limestones are devoid of recognizable species except corals. Fossils are noticeably less abundant than above. Corals of three species prevailing, *Amplexus irregularis, Heliophyllum Halli, Striatopora limbata.* Trilobites: *Phacops rana* rare. Cephalopods: *Orthoceras exile* rare. Gastropods: *Diaphorostoma lineatum, Platyceras Thetis* rare. Lamellibranchs: *Pterinopecten undosus, Palæoneilo fecunda* rare. Brachiopods: *Stropheodonta inæquistriata, Spirifer audaculus, Orthothetes arctostriata, Orbiculoidea media, Lingula* cf. *densa*; all rare. Crinoids: *Megistocrinus depressus*, one specimen.
427	Thin, hard, blue-gray concretionary coral limestone, with *Heliophyllum Halli, Favosites Argus, F. arbusculus, Eridophyllum Archiaci.* Other fossils with exception of *Diaphorostoma lineatum* exceedingly rare.

429	Soft gray-blue shales. *Lingula spatulata* very abundant. *Phacops rana, Stropheodonta Junia, Cryptonella planirostra, Platyceras Thetis, P. bucculentum, Diaphorostoma lineatum* abundant.
430	Fine-grained, pinkish-gray limestone, with few fossils; *Stropheodonta Junia* predominating. *S. inæquistriata* and *Orthis Vanuxemi* common.
431	Blue shales, alternating with hard concretionary layers, containing corals. Fossils not abundant, the predominant species being *Cystiphyllum americanum, Heliophyllum Halli, Favosites Canadensis, Eridophyllum Archiaci, Stropheodonta Junia.* *Phacops rana* rare; *Orthoceras nuntium* rare; *Platyceras* and *Diaphorostoma* occasionally. The only lamellibranch *Grammysia alveata. Stropheodonta inæquistriata, S. perplana* and *Orthis Penelope* also occur.
438	Hard, calcareous layer with pyrites. The only fossils observed, *Stropheodonta Junia, S. inæquistriata.*
440	Soft, compact, blue shales, with occasional thin calcareous layers. Fossils abundant. At 467–469 the fossils are largely preserved in pyrite, and the fauna at this level is in some respects different from that above and below. TRILOBITES: *Phacops rana* and *Proetus macrocephalus* common; *Cryphæus Boothi, Homalonotus DeKayi* and *Proetus Rowi* less frequent.
....	....

Cephalopods: Rare. *Goniatites uniangularis* the most common. Other species, *Orthoceras nuntium, O. emaceratum, Nautilus bucinum, N. magister, Gomphoceras* cf. *Fischeri.*

Gastropods: *Diaphorostoma lineatum, Pleurotomaria Itys, P. capillaria, P. lucina, Loxonema Hamiltoniæ,* abundant; *Platyceras Thetis, P. symmetricum* common; *P. echinatum, P. attenuatum, P. bucculentum, Pleurotomaria* cf. *filitexta* occasionally.

Pteropods: *Hyolithes aclis* common; *Styliolina fissurella* occasionally.

Lamellibranchs very abundant: The prevailing species are *Lyriopecten orbiculatus, Plethomytilus oviformis, Actinopteria decussata, Pterinopecten undosus* and *Cypricardinia indenta. Cimitaria corrugata, Modiomorpha mytiloides, M. concentrica, Aviculopecten princeps* are common, and the following species are more rarely observed: *Pterinea flabella, Cypricardella bellistriata, Macrodon Hamiltoniæ, Tellinopsis subemarginata, Nucula lirata, Palaeoneilo fecunda, P. constricta, Nucula bellistriata, Nuculites subcuneatus,* sp. nov. *Grammysia alveata, Phthonia cylindrica, Modiella pygmæa, Goniophora angulata, Modiomorpha macilenta, Panenka* cf. *æquilatera, Pterinopecten vertummus.*

Brachiopods abundant: The prevailing species are *Stropheodonta concava, Spirifer mucronatus, S. audaculus, Chonetes scitula* and *Athyris spiriferoides,* and *Liorhynchus multicostatus* in a thin layer at 462 feet. The following are common: *Stropheodonta inæquistriata, Orthis Vanuxemi, Chonetes deflecta, C. coronata, Stropheodonta nacrea, Spirifer fimbriatus, Meristella Haskinsi, Trematospira hirsuta, Tropidoleptus carinatus.* Those of less frequent occurrence are *Orbiculoidea humilis, Crania Hamiltoniæ, Lingula Leæna, Orthothetes arctostriata, Stropheodonta perplana, Productella spinulicosta, Orthis Penelope, Ambocœlia umbonata, A. præumbona, Rhynchospira lepida, Pentamerella Pavilionensis, Terebratula Ontario.*

Bryozoa: *Stictopora incisurata* abundant; *Reptaria stolonifera, Lichenalia stellata, Tæniopora exigua, Reteporina perundulata* common; *Hederella cirrhosa* occasionally.

Echinoderms very rare: *Nucleocrinus Lucina* only.

Alcyonaria. *Ceratostigma papillata,* sp. nov.

....	....
467	Shales with fossils in pyrite. *Cryphæus Boothi* very abundant, no other trilobites. *Orthoceras exile, O. subulatum, O. nuntium, O. emaceratum* prevail. Species not occurring in the enclosing fauna are *Bellerophon Leda, Holopea* sp. n.?, *Hyolithes* sp.?, *Pholadella parallela, P. radiata, Phthonia nodocostata, Nuculites* sp.n., *Grammysia arcuata, Schizodus appressus, Pholidops Hamiltoniæ.*
	GRAPTOLITES: *Dictyonema Hamiltoniæ*, common. CORALS: *Favosites arbusculus, F. Argus, Pleurodictyum stylopora* common; *Eridophyllum Archiaci, Striatopora limbata, Trachypora elegantula, Streptelasma rectum* occasionally.
473	Blue shales, slightly harder and more calcareous. At 476–478 is intercalated a concretionary layer containing pyrites and some fossils in a silicified condition. Fossils comparatively abundant and uniformly distributed.
476	Concretionary layer with silicified fossils. *Loxonema Hamiltoniæ* (large), *Ambocœlia umbonata, Chonetes* sp., and *Spirifer audaculus* prevail. *Cryphæus Boothi, Athyris spiriferoides, Strophalosia truncata, Striatopora limbata* and *Trachypora elegantula* common.
	TRILOBITES: *Phacops rana* and *Cordania gemmea* only observed, the former abundant. CEPHALOPODS: The fauna is characterized by the great abundance of *Orthoceras Œdipus.* Other species observed are *O. nuntium, O.* cf. *nuntium, O. aulax, Goniatites Vanuxemi, Gyroceras* sp. GASTEROPODS: *Loxonema Hamiltoniæ, Pleurotomaria Lucina* and *Bellerophon Leda* common. Of less frequent occurrence are *Diaphorostoma lineatum, Pleurotomaria capillaria,*
....	....

P. Itys, *P. rugulata*, *Cyrtolites mitella*, *Bellerophon patulus*, and *Platyceras Thetis*.

LAMELLIBRANCHS: Quite abundant and diversified, *Plethomytilus oviformis*, *Goniophora Hamiltoniæ* and *Cypricardella bellistriata* are predominant. The commoner species are *Modiomorpha mytiloides*, *Grammysia arcuata*, *Actinopteria decussata*, *Nucula lirata*, *Palæoneilo plana*. Those of occasional occurrence, *Cardiola retrostriata* (one), *Lunulicardium fragile*, *Palæoneilo constricta*, *Nuculites triqueter*, *Pterinopecten vertumnus*, *Orthonota parvula*, *Schizodus appressus*, *Phthonia nodocostata*, *Modiella pygmæa*, *Liopteria Greeni*, *Macrodon Hamiltoniæ*, *Aviculopecten princeps*, *Tellinopsis subemarginata*.

BRACHIOPODS: Prevailing species, *Chonetes lepida*, *Ambocœlia umbonata*, *Spirifer audaculus*, *Tropidoleptus carinatus*, *Orbiculoidea media*. Others of common occurrence, *Stropheodonta perplana*, *S. nacrea*, *Spirifer granulosus*, *S. mucronatus*, *Athyris spiriferoides*, *Productella spinulicosta*, *Chonetes scitula*, *Lingula* cf. *densa*, *Pholidops Hamiltoniæ*. The following are occasionally observed: *Orthis Vanuxemi*, *Trematospira hirsuta*, *Stropheodonta concava*, *Nucleospira concinna*, *Cyrtina Hamiltonensis*, *Orthothetes arctostriata*, *Terebratula Ontario*.

CORALS: Very few. *Pleurodictyum stylopora*, *Streptelasma rectum* occasionally; *Favosites Argus* rarely.

495	At this level the shales become less blue, more slaty and with cleaner cleavage, and the fauna rapidly changes. Toward the bottom of this mass the shales become very black and bituminous. Fossils much less abundant than above and not uniformly distributed, but in thin beds at distinct horizons. Thus *Liorhynchus multicosta* is very abundant at 495, where a thin layer is composed of it; *Modiomorpha subalata* at 505; *Goniatites uniangularis* and *Lunulicardium fragile* abound at 510, and *Styliolina fissurella*, with undetermined plant remains, at 512. The other commoner species are *Chonetes scitula*, *Ambocœlia præumbona* and an undetermined form of *Panenka*. Those of less frequent occurrence are *Ambocœlia umbonata*, *Productella spinulicosta*, *Spirifer mucronatus*, *Pleurotomaria rugulata*, and an undescribed, perhaps new, form of *Goniatites*.

515 The shales become softer and blue-grey, and there is a gradual return of the normal fauna. The fossils, however, are still massed in thin layers with intervening barren sediments.

At 518 is a thin layer of *Liorhynchus multicosta*, at 522 one of *Orthothetes arctostriata*, and at 524 one of *Liorhynchus quadricostata*. *Orbiculoidea media*, *Ambocœlia umbonata* and *Modiomorpha subalata* are everywhere abundant. *Phacops rana* in fine examples, and *Cryphaeus Boothi* abound toward the base of the series.

No other Trilobites were observed.

Cephalopods are rare; represented by occasional examples of *Goniatites uniangularis*, *Orthoceras nuntium* and *O. exile*.

Gastropods: *Bellerophon Leda*, *Pleurotomaria Itys* and *Loxonema delphicola* are common; *Pleurotomaria trilix*, *P. rugulata* and *Cyrtonella mitella* are also found.

Lamellibranchs: *Modiomorpha mytiloides*, *Palæoneilo fecunda*, *P. constricta* are common; *Cypricardella bellistriata*, *Nucula bellistriata*, *Aviculopecten exacutus*, *Cypricardinia indenta*, *Panenka æquilatera*, *Lunulicardium* cf. *fragile* and *Nuculites triqueter* are the occasional species.

Brachiopods: *Chonetes scitula*, *C. coronata*, *C. deflecta*, *Ambocœlia præumbona*, *Stropheodonta perplana*, *Athyris spiriferoides*, *Atrypa reticularis*, *Spirifer granulosus*, *Orthis Vanuxemi*, *Lingula Leœna*.

Bryozoa absent.

Corals very rare; only *Streptelasma rectum* and *Romingeria* sp. ?

....	....
543	Similar blue-grey shales with some pyrite as far as 550 and a more general diffusion of fossils. At 543 small individuals of *Goniatites uniangularis* in pyrite are abundant; at 550 is a mass or layer of *Striatopora limbata* with *Spirifer sculptilis* and *Meristella Haskinsi* in great numbers. At 555 is a layer of CORALS: *Heliophyllum Halli* and its varieties, *Amplexus intermittens*, *Streptelasma rectum*, *Romingera* sp.?, *Favosites Canadensis*, sp.?, *Striatopora limbata*, *Eridophyllum Archiaci*, all abundant. Elsewhere in the mass the prevailing fossils down to 565 feet are: *Phacops rana*, *Bellerophon Leda*, *Pleurotomaria Itys*, *Cypricardinia indenta*, *Palæoneilo fecunda*, *Plethomytilus oviformis*, *Lyriopecten orbiculatus*, *Actinopteria decussata*, *Cypricardella bellistriata*, *Spirifer audaculus*, *S. divaricatus*, *S. fimbriatus*, *Stropheodonta concava*, *S. perplana*, *Athyris spiriferoides*, *Atrypa reticularis*, *Chonetes deflecta*, *Stictopora incisurata*, *Polypora latitruncata*, *P. undulata*. The less common species are: *Cryphæus Boothi.* *Orthoceras exile*, *O nuntium.* *Pleurotomaria trilix*, *P. Lucina*, *Diaphorostoma lineatum*. *Modiomorpha macilenta*, *Liopteria Greeni*, *Goniophora truncata*, *Aviculopecten exactus.* *Terebratula Romingeri*, *Stropheodonta inæquistriata*, *Orthis Vanuxemi*, *Crania Hamiltoniæ*, *Chonetes coronata*, *Trematospira hirsuta.*
....	....

560	Light grey subcrystalline limestone (Encrinal limestone). Prevailing species, *Actinopteria decussata*, *Lyriopecten suborbicularis*, *Terebratula* sp. (large), *Chonetes coronata*, *Athyris spiriferoides*, *Meristella Haskinsi*, *Orthis Vanuxemi*, *Productella spinulicosta*. Species of less frequent occurrence, *Phacops rana*, *Stropheodonta demissa*, *S. nacrea*, *S. concava*, *S. inæquistriata*, *Spirifer audaculus*, *Rhynchonella Sappho*.
562	Soft, dark shales, heavy-bedded, considerably bituminous, with fossils in thin layers, the intervening rocks being barren. At 578 a thin bed composed of *Ambocœlia umbonata*. The most abundant species in all the fossil bands is *Liorhynchus multicosta*, which frequently prevails almost to the exclusion of other species. The composition of the fauna in other respects, and taken as a whole, is as follows: TRILOBITES: None. OSTRACODES of various species common. CEPHALOPODS: *Gonatites uniangularis* and *G.* sp., both rarely. GASTROPODS: None. PTEROPODS: *Pharetrella tenebrosa* rare. *Styliolina fissurella* very common. LAMELLIBRANCHS: *Lunulicardium fragile*, *Modiomorpha subalata*, *Nuculites Nyssa*, common; *Paracyclas lineatus*, *Aviculopecten princeps*, *Nuculites triqueter*, *Modiella pygmæa*, *Palæoneilo fecunda*, *Lunulicardium Livoniæ*, sp. nov. *Panenka æquilatera*, *P. retusa*, *Liopteria lævis*, *Phthonia nodocostata* less abundant. BRACHIOPODS: *Chonetes scitula*, *Spirifer mucronatus* (small variety), *Productella spinulicosta*, *Orbiculoidea media* common; *Stropheodonta perplana* rarely. PLANT REMAINS, stipes and twigs, unidentifiable, common.

650 The shales become very bituminous, compact and heavy-bedded, not changing in character for the entire thickness to 797 feet. The fossils are few, and distributed in thin beds as above. The character of the rock is very similar to that in the more bituminous beds of the Genesee.

Lunulicardium fragile, *Liorhynchus limitaris*, *Chonetes lepida*, *C. mucronata*, and plant remains are everywhere abundant, *Goniatites uniangularis*, *Orthoceras exile?*, *Liopteria lævis*, *Phthonia lirata* or sp., and *Ambocœlia umbonata* occur frequently; *Phacops rana*, *Cryphæus Boothi*, *Bellerophon Leda*, *Pleurotomaria rugulata*, *Nuculites* sp., *Modiella pygmæa*, *Cardiola Doris?*, *Panenka* sp. n. ? are occasionally found.

The approximation of this fauna to the normal fauna the black fissile Marcellus shales is apparent in the preponderant species.

797	The shales are still black, very bituminous and compact, with an irregular cross-bed fracture. At 803 is a layer containing *Orbiculoidea minuta* in great quantities, and *Goniatites uniangularis, Pleurotomaria rugulata, Styliolina fissurella, Productella spinulicosta* very abundantly; *Modiella pygmæa* and *Liopteria lævis* are also common at the same horizon. Elsewhere fossils are rare, only *Orthoceras subulatum* and *Bellerophon*, *Leda* having been observed.

....	....
812	The shales are still bituminous, but decidedly more calcareous than above. The prevailing species are: *Goniatites uniangularis* (a small form), *Pleurotomaria rugulata* (composing entire layers), *Lunulicardium fragile, Actinopteria muricata, Liorhynchus limitaris* (in layers), *Productella spinulicosta, Strophalosia truncata, Orbiculoidea minuta, Hyalostelia ? Marcellia* sp. nov. The following are of less frequent occurrence: *Orthoceras subulatum, Liopteria lævis, Cardiola retrostriata, Actinopteria* (small) sp. ?, *Panenka æquilatera, Modiomorpha* cf. *subulata, Escharopora* sp. Rarer species are: *Orthoceras nuntium, Cyrtoceras* sp. ?, *Diaphorostoma* sp. ?, *Pleurotomaria capillaria, Panenka* sp. ?, *P. Lincklaeni, Lucina ? Livonensis, Pterinopecten dignatus, Nuculites triqueter, Reptaria stolonifera.*
823	A compact, greyish or chocolate-colored limestone, somewhat bituminous, shaly at the top. (Stafford limestone.) Hamilton fossils very abundant. Prevailing species: *Phacops rana, Meristella Barrisi, Rhynchonella Horsfordi, Chonetes scitula, Strophalosia truncata.* Of frequent occurrence are: *Pleurotomaria Itys, Loxonema delphicola, Rhynchonella Sappho, Ambocœlia umbonata, Chonetes mucronata, Orthothetes arctostriata, Spirifer subumbona, Panenka æquilatera, P. Lincklœni, Pterinopecten exfoliatus, Styliolina fissurella.* These others were identified: *Cryphæus Boothi, Orthoceras* cf. *Marcellense, O. Oedipus, Pleurotomaria sulcomarginata, P. Lucina, Actinopteria muricata, Aviculopecten bellus, Atrypa reticularis, Rhynchospira* cf. *Eugenia, Spirifer audaculus, Reptaria stolonifera.*

825	Compact black, very bituminous but not heavy-bedded shales. This is the horizon of *Paneka Lincklaeni*, which is very abundant and often of great size. Other abundant fossils are *Nuculites Nyssa*, *Lunulicardium fragile*, *Liopteria lævis*, *Liorhynchus limitaris*, with many undeterminable plant remains. Common fossils are plates of *Aspidicthys* and *Coccosteus halmodeus*, sp. nov. *Goniatites uniangularis*, *Orthoceras subulatum*, *Styliolina fissurella*, *Pterinopecten dignatus*, *N. lætus*, *Actinopteria muricata*, *Orbiculoidea minuta*, *Chonetes mucronatus*. Other species observed: *Onchodus* cf. *Hopkinsi* (tooth), *Orthoceras nuntium*, *Cyrtoceras citum*, *Panenka æquilatera*, *P.* sp. n., *Lunulicardium curtum*.
829	Unfossiliferous black shales with symmetrical calcareous concretions to 851.
....	....
....	....
851	Black shale filled with *Orbiculoidea* like *O. minuta*, but of large size. With it occur the following species: *Goniatites uniangularis*, *Pleurotomaria rugulata*, *Nuculites Nyssa*, *Panenka æquilatera*, *Lunulicardium* sp. nov., *Liorhynchus limitaris*.
852	Impure argillaceous somewhat bituminous limestone largely composed of *Tentaculites gracilistriatus*. No other fossils observed.
854	Greyish black limestone, purer than above, with abundant fossils, some of which are known elsewhere only in the Corniferous limestone. Prevailing species: *Tentaculites gracilistriatus*, *Orthothetes bellulus* sp. nov., *Chonetes lineata*. Common species: *Phacops rana*, *Spirifer audaculus*, *Stropheodonta inæquistriata*, *Ambocœlia umbonata*, *Athyris spiriferoides*, *Pholidops Hamiltoniæ*, *Orthis* cf. *lenticularis*, *Cœlospira Camilla*, (small var.) *Chonetes deflecta* (coarse var.) *C.* cf. *Yandellana*, *Aviculopecten* cf. *fasciculatus*, *Modiomorpha subalata*. Other species observed: *Goniatites uniangularis*, *Orthoceras subulatum*, *O. incarceratum* sp. nov., *O. Lima*, *Pleurotomaria Lucina*, *Nuculites oblongatus*, *Cypricardinia indenta*, *Cypricardella bellistriata*, *Modiomorpha concentrica*, *Palæneilo plana*, *Stropheodonta perplana*, *Tropidoleptus carinatus*, *Orthothetes Pandora*, *Terebratula* sp.? *Stictopora incisurata*, *Streptelasma rectum*.
856	Impure limestone like that at 852, composed largely of *Tentaculites gracilistriatus* with a few other species, viz.: *Goniatites uniangularis*, *Chonetes lineata*, *C.* cf. *deflecta*, *Liorhynchus limitaris*.

857	Black shales, not calcareous. No fossils but *Styliolina fissurella* which abounds.
863	Irregular concretions with much carbonaceous matter and pyrite. No fossils.
864	Hard, black calcareous shale, abounding in *Styliolina fissurella* and *Liorhynchus limitaris.* A single specimen of a very large *Panenka*, cf. *P. Lincklaeni.*
866	Thin layer of small crinoid stems.
867	Dark, even grained, compact limestone, without chert. *Leptœna rhomboidalis, Atrypa reticularis, Phacops pipa* abundant. *Orthis propinqua, Pentamerella arata, Stropheodonta demissa, Spirifer varicosus, Stictopora Gilberti,* common. *Strophonella ampla* rare, also a fragment of *Lichas* sp.?

871	From this point to 954 grey limestones alternate with continuous or nodular layers of chert. The former are from one-half to five feet in thickness and vary little in lithological character or in the nature of the fossils. The alternation of limestone and chert is irregular, the latter usually in thin layers, but the amount of chert gradually increases downward. At 888 is the remarkable layer, four inches thick, composed of a mass of crystal scales of gypsum in an amorphic gypsum base. This is in juxtaposition on its upper surface with a very thin layer of comminuted crinoids. Few fossils have been observed in the chert. The predominant forms in the limestone are: *Phacops pipa*, *Euomphalus* sp. nov.?, *Chonetes lineata*, *Atrypa reticularis*, *Cœlospira Camilla*, *Ambocœlia umbonata*, a very small variety in masses at 943. Common species are: *Proetus clarus*, *Odontocephalus selenurus*, *Orthis lenticularis*, *Stropheodonta hemisphærica*, *P. inæquistriata*, *Orthothetes Pandora*, *Leptæna rhomboidalis*, *Athyris spiriferoides.* The following are rarely observed: *Cyrtoceras* sp.?, *Gyroceras trivolve?*, *Orthoceras tetricum*, *Platyceras* sp. nov., *Stropheodonta perplana*, *Spirifer duodenarius*, *S. fimbriatus*, *Aviculopecten* sp.?

954	The chert increases and is very irregularly distributed without apparent division into layers. At 995 the chert begins to diminish and disappears at 998½. No fossils observed.
998½	Grey limestone, with corals containing oil. No chert. *Phacops bombifrons* very abundant. Corals poorly preserved. *Favosites tuberosus, Syringopora, Zaphrentis* sp.
1001	Hard, compact sandstone, dark green where finest, with streaks, splotches and tubes of coarse lighter-colored quartz grains mingled with green chloritic scales. This lighter quartz sand increases downward becoming a cement holding large irregularly rounded masses of dark bituminous hydraulic limestone and some of a drab, purer limestone. The few fossils which have been determined are in the sandy cement and are usually visible only in transverse sections. (Schoharie grit +Oriskany sandstone.) The most frequently occurring shell is an undescribed pentameroid of the type of *P. arata*, but with fuller umbones and highly variable exterior. Some of the specimens are strongly plicate about the margins, but usually these plications are quite obsolete except for low irregular radial undulations, the shell having thus a smooth exterior. The other fossils observed are *Atrypa reticularis, Orthis* cf. *propinqua*, fragment of a large finely-striated orthoid, perhaps *Hipparionyx proximus, Stropheodonta*, large species, *Zaphrentis* sp.?, *Pentagonia unisulcata*, small form, *Spirifer*, large species, cf. *arenosus*.
1006	Highly bituminous, dark chocolate-colored hydraulic limestone with crystallizations of calcite and celestite in small masses, sometimes filling cavities. No fossils.

1010	Compact hydraulic limestone, somewhat lighter colored, and purer, without well-defined lamination lines at the top. No mineral crystallizations of large size. In the upper strata to 1014, *Spirifer Vanuxemi* is very abundant in three layers, with an occasional *Leperditia alta*, and still more rarely a small *Leperditia* sp. indet. Below 1014 *Stropheodonta varistriata* abounds and Sp. *Vanuxemi* is less common. *Liopteria rugosa* also occurs in the lower layers.
1045	Chocolate hydraulic limestone with small *Favosites*.
1105	Thin hydraulic layers with a large *Leperditia* like *L. alta*; the lowest fossiliferous horizon in the section.

THREE HUNDRED AND TWENTY-SEVEN FEET TO BASE OF SHAFT.

The more interesting features in this succession of the faunas are somewhat obscured and too briefly expressed in such a tabulation as the foregoing.

Following the sequence in its natural order from beneath upward, the first fossil encountered in the great thickness of hydraulic limestone overlying the salt, is a large sized *Leperditia* like *L. alta* and *L. Jonesi* in size and form and also resembling the species occurring in the Coralline limestone at Schoharie which was originally identified as *L. alta.* It would perhaps be difficult to say whether this is actually the characteristic species of the Tentaculite limestone (*L. alta*) appearing so early, or, if this is the case, whether the same species has not maintained an unmodified existence from the late faunas of the Niagara period. Our specimens being in the form of casts do not permit the determination of so nice a point. The favosite occurring at 1045′ also determines nothing, but from above this point where the lithological character of the rock changes noticeably, to 1010′ we have a well-developed Tentaculite limestone fauna.

It is a noteworthy fact and one that has been frequently adverted to, that the Lower Helderberg series of strata loses its differentiation westward in New York beyond the region of its typical exposure; and the faunas of these separate divisions also lose their individuality. With the thinning of the formation to the west the faunas become commingled, more and more sparse, with a notable prevalence of that of the Tentaculite limestone, the basal member of the series, until finally, as shown in the Livonia section, the entire group is represented by a thickness of about thirty-five feet containing a fauna wholly composed of Tentaculite limestone species.

The nearest point to the eastward of the Livonia meridian where a good exposure of the Lower Helderberg rocks has been carefully studied is near Union Springs in Cayuga county, at which place Prof. Williams has shown* the presence of a considerable element from the upper faunas of the Lower Helderberg group, represented by such species as *Orthostrophia strophomenoides*, *Nucleospira ventricosa*, etc.

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* American Journal of Science, September, 1885, and February, 1886; Report of New York State G logist for 1886, p. 10.

No evidence is afforded by the Livonia section as to the horizon of the *Eurypterus* and *Pterygotus* beds. This, of itself, is a negative fact of interest, showing an absence or sparsity of these crustaceans through this west-central region of the State, which is confirmed by outcrops of adjoining counties; while they abound to the westward, in Erie county, and to the east, in Oneida and Herkimer counties. Mr. Luther reports the finding of a specimen of *Eurypterus* in an outcrop near Phelps, Ontario county, which, without precise measurement, he thinks represents an horizon not more than twenty feet below the base of the Oriskany sandstone at that place; and Prof. Williams, in the paper cited, mentions a fragment of *Pterygotus* in association with the other fossils noted. This evidence, however, is insufficient to justify the assumption that the *Eurypterus* fauna is an integral part of that of the Tentaculite limestone, or to disturb the conviction that this crustacean in its full development characterizes the closing part of the Waterlime group. As shown by Prof. Hall,* the *Eurypterus* beds in Oneida county, where exposed in conjunction with the Tentaculite limestone, are clearly seen to pass beneath the latter, and where the former are so prolific in life, to the west in Erie county, the Tentaculite limestone is wanting.

The stratum at 1,001 feet, with its fauna, constitutes one of the most interesting features of this section. It is a conglomerate of blocks of hydraulic limestone cemented by a paste of silicious sand. The hydraulic blocks have evidently been derived from the strata beneath, but they have furnished no fossils, all traces of organic life having been obtained from the sandy cement. These fossils are not well preserved and show evidence of having been tossed about by the waves, broken and macerated. The most frequently occurring species is a very variable form of *Pentamerella* not unlike *P. arata* when the surface of the valves is plicated, but very unlike that species when its surface is (naturally, not accidentally) devoid of plication. While it is natural to regard this sandstone formation as a westward extension of the Oriskany, this conclusion is not fully justified. Among the identifiable fossils there is no single char-

* Palæontology of New York, vol. 3, p. 385, 1859.

acteristic Oriskany sandstone species, though there is a large orthoid suggestive of *Hipparionyx proximus*, a large *Stropheodonta* and a large *Spirifer* which may prove to be *S. arenosus*. These are all unlike forms occurring in Upper Helderberg faunas and, as far as the fragments show, have an Oriskany sandstone aspect. On the other hand, the presence of the *Pentamerella* referred to, of *Pentagonia unisulcata* and an *Orthis* comparable to *O. propinqua*, indicate a positive Upper Helderberg element in the fauna; and it has hence been suggested that this four feet of sandstone represents a commingling of the faunas of the Oriskany sandstone and Schoharie grit, a repetition on a small scale of the concurrence of the two faunas observed in the province of Ontario.

The separation of this stratum from the overlying upper Helderberg limestones is sharp, the delimitation of these limestones being very clear both above and below. With its base at 1001 feet and its upper limit at 866½ feet it has a total thickness of 134½ feet, of which but two and a half feet at the base can be referred to the Onondaga limestone. The 132 feet of Corniferous limestones is free of soft shale and not especially abundant in fossils. The most striking character of the limestones throughout their extent is the remarkable paucity of corals; all the more surprising from their amazing abundance in these limestones a little further to the west, in Genesee county, about LeRoy.

The succession of faunas in the Marcellus group is most interesting and instructive. Above the topmost layer of Upper Helderberg limestone is a thin stratum composed of washed crinoidal fragments (866 feet) and immediately above appear bituminous shales with large Panenkas, *Liorhynchus limitaris* and *Styliolina fissurella.* At 856 and 852 feet are two layers of an impure argillaceous limestone, quite alike in lithological characters and largely composed of *Tentaculites gracilistriatus.* These two layers, the upper about twice the thickness of the lower, are separated by a two-foot bed of a purer limestone of a different aspect. The fauna of this layer is comparatively prolific and the list of species given in the section is worthy of close inspection. The fossils are not those characteristic of the Marcellus shales, properly speaking, but we meet here for the first time many of the forms of the Hamilton shales, commingled with stragglers from the Upper Helderberg fauna beneath, which, however, during the period of their migrations and descent have not escaped modification. Such are an *Orthis*, like *O. lenticularis*, a small form of *Cœlospira Camilla* which is quite abundant, *Chonetes* like *C. Yandellana* and a small form of *Orthothetes Pandora*. The stratum has also furnished two new species, *Orthoceras incarceratum* and *Orthothetes bellulus*. In the bed of impure limestone lying immediately beneath, *Chonetes lineata*, a Corniferous species, has also been observed in association with *Liorhynchus limitaris*.

Above 852 feet are twenty-eight feet of black bituminous shales, quite abundantly fossiliferous at top and bottom with the characteristic species of this group, but in the middle barren of organic remains. Then follows a two-foot compact chocolate limestone which I have termed the Stafford limestone from its excellent development at Stafford, Genesee county; a stratum persistent from Livonia eastward to an unknown distance, probably not less than fifty miles. In the shaft section, as at all its observed outcrops, it bears a Hamilton fauna with a few of the Marcellus shale species, all usually in a fine condition of preservation. From this horizon upward there are no more limestones in the Marcellus section. The shales which begin at 822 feet bear almost exclusively species characteristic of the group, but in the course of fifty feet there is a gradual appearance of Hamilton fossils, which have before been met with only in the limestone layers beneath. This presence of Hamilton species becomes perceptible at once above 794 feet and more strongly expressed throughout the thick bed of black, bituminous shale extending from this point to 650 feet. The passage of these black shale beds of the Marcellus, with their fauna, into the Hamilton division with its fauna is imperceptible. From the Stafford limestone at 823 feet up to the base of the Encrinal limestone at 562 feet there is a gradual lessening of bituminous matter in the shales, a progressive increase in their argillaceous character, and likewise a gradual disappearance of the Marcellus species and a progressive increase of those characteristic of the shales above. We may approximately and quite conventionally place the upper limit of the Marcellus at about 650 feet, but above this horizon both the organic and physical composition of the strata are for a considerable extent suggestive of the beds beneath. The differences in the succession here and at the nearest section to the eastward where the faunas have been carefully studied, are quite marked. Along the meridian of Canandaigua lake, in Ontario county, the black Marcellus shales are capped by several feet of light gray limestones (*basal limestones**), rich in the characteristic forms of the Hamilton division and especially prolific toward the top in corals. These pass gradually into a considerable thickness of argillaceous shales above, which are interrupted by a sudden and brief return of the black shales with the Marcellus fauna. This returning fauna has been described by the writer as "recurrent Marcellus" and its appearance has been noted by Dr. D. F. Lincoln still further eastward on the shore of Seneca lake. But in Livingston county the basal limestones with their rich fauna have disappeared. There is no good evidence of an abrupt return of the black shales and their fossils, but the entire lower portion of the Hamilton division is a mass of dark compact and very sparsely fossiliferous shale beds characterized by their distinct layers of *Liorhynchus multicosta.*

The great beds of highly fossiliferous Moscow shales overlying the Encrinal limestone at 560 feet vary so little in physical characters and the composition of their faunas throughout their extent and to the top of their section that a recapitulation of their relations is unnecessary.

The Geological horizons of the recorded section of the Livonia Shaft and their thickness briefly stated.

Hamilton group	Upper or Moscow shales	225′ — 560′ = 345′
	Encrinal limestone	560′ — 562 = 2′
	Lower shales	562′ — 650 = 98
Marcellus group		650′ — 866½′ = 216½′
Corniferous limestone		866½′ — 998½′ = 132½′
Schoharie grit		1901′ — 1006′ = 5′
Oriskany sandstone		
Tentaculite limestone		1006′ — 1045(?) = 39′
Waterlime group		1045′ (?)

* Clarke in Annual Report of State Geologist for 1886.

New or Rare Species of Fossils from the Horizons of the Livonia Salt Shaft.

By John M. Clarke.

New or Rare Species of Fossils from the Horizons of the Livonia Salt Shaft.

Coccosteus (?) halmodeus, sp. nov.

Plate I, figs. 1, 2.

From the level of 825–828 feet in the Shaft in the densely bituminous, blocky layers of the Marcellus shales, a number of specimens of placoderm fishes was obtained, some of them of large size, coarsely tubercled, and similar to the plates which have been termed *Aspidicthys* by NEWBERRY and VON KOENEN. Of others, two belong to a fish evidently coccostean in its relations, and as one of these is in a quite unusual condition of preservation for a fish from the Devonian shales of New York, it seems desirable to give some account of it, especially as it is believed to present some interesting, if not novel, structural features.*

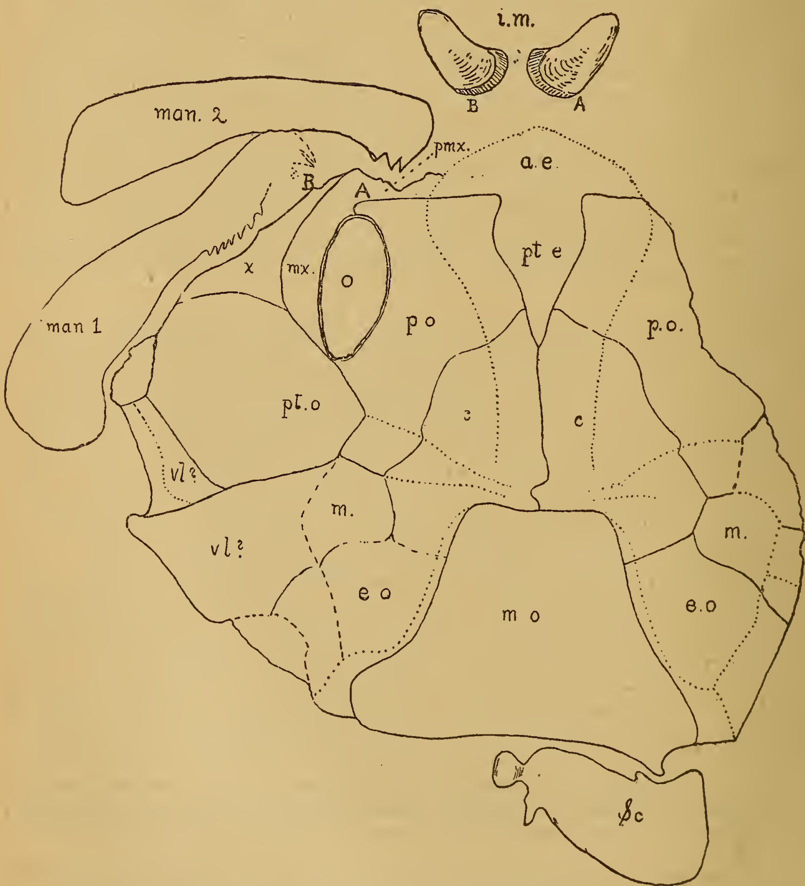
This specimen presents the nearly entire dorsal aspect of the cranium, with, at the left, perhaps a portion of the plates of the ventral side. All of these plates are in very close articulation, although the entire armature has been compressed. About the main body of plates lie some scattered fragments near the posterior region, and, to the left and above, two denticulated mandibles, to which detailed reference will be duly made.

The exposure is a clean dorsal surface, showing with great clearness the distribution of the coarse and fine granules upon the plates. The sutures of the plates are, however, extremely obscure, while the sensory canals are very distinct; in consequence it has been difficult to determine in all instances whether certain of these lines are to be regarded as the one or the other.†

* The writer pretends to no accurate knowledge of piscine osteology. No other attempt is here made than to present the structure of this fossil so far as it can be made out satisfactorily, and in this form to submit the account to the criticism of those more expert in this department of research.

† "The reading of the cranial buckler of *Coccosteus* is much complicated, by the fact that certain superficial grooves belonging to the lateral-line system are very conspicuous and apt to be mistaken for sutures, while the true sutures are visible with difficulty and can only be made out in exceptionally well-preserved examples." (TRAQUAIR, loc. cit., p. 4.)

In considering the fossil a coccostean fish, of which there seems to be no reasonable doubt, one of the most striking and peculiar characters is the expansion of the shield at the left, where it has unfortunately been impossible to make out the structure in full detail; but it is here, presumably, that some of the infra-orbital plates on one side have been turned upward. In the lithographic figure here given of this specimen (Plate I, fig. 1), no attempt has been made to distinguish between the sutures and the sensory canals, the latter appearing the more conspicuously. The object of the figure is to give the general aspect of the specimen. The accompanying diagram, how-



ever, will serve to bring out these features as far as it has been safely possible to go, the actual sutures being represented by continuous lines, probable or possible sutures by dotted lines, and the sensory canals by broken lines. To explain this figure, a copy of the restoration of the composition of the cranium of *Coccosteus decipiens*, Agassiz, as made out by Traquair * and a portion of a side view given by Lydekker,† are also introduced, the lines having the same meaning in all the figures and the lettering of the plates being the same.

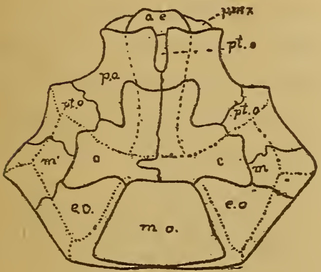


Fig. 1 —Restoration of the top of the head in *Coccosteus decipiens*. (Traquair.)

Fig. 2—Right lateral aspect of the head (Lydekker.)

The proportions of this specimen compared with those of the best known representatives of the genus, *C. decipiens*, Agassiz, and *C. inflatus*, von Koenen,‡ are large, but compare well in size to that described by Whiteaves as *C. acadica*.§

Sensory canals. These conspicuous features of the cranium converge near the center of the shield just in front of the median occipital plate (*m. o.*). They do not come in contact at this place, either with one another or with the true sutures. The most distinct pair makes a double curve anteriorly and becomes continuous at the anterior extremity of the specimen, inclosing a clavate area. These canals must have been very deep and hence formed lines of weakness in the shield when under compression,

* Geological Magazine, Dec. III, vol. VI, pp. 1-8, pl. 1, 1889; Proc. Roy. Phys. Soc. Edinb. Vol. X, pp. 47-57, pl. 3.

† Nicholson and Lydekker, Manual of Palæontology, vol. II, p. 965, 1889.

‡ The writer had the opportunity, some years ago, of studying and making sketches of the original of this species, from the Devonian of Bicken, though von Koenen's paper (Beitr. zur Kenntniss der Placodermen Fische, 1883) is not now accessible to him. The restored figure of this species is, however, reproduced in Zittel's Handbuch der Paläontologie (vol. III, p. 160, fig. 167, 1890).

§ Canadian Naturalist, vol. X, p. 94, 1881, and Trans. Roy. Soc. Canada, vol. VI, p. 93, pl. IX, 1888.

as there appears to be a slight fracture and displacement along one of them. Two symmetrical pairs diverge laterally over the surface of the central plates (*c*), the posterior pair being the shorter; a fourth pair follows the curvature of the median occipital plate, just outside of it, curves upward near the post-lateral extremities of the shield and gives off two short branches to the margin. The further course of these canals cannot be made out.

Plates. The *ethmoid* (*a. e.*, *p. e.*) has a lanceolate outline and no suture between its anterior and posterior divisions can be distinguished. The sharp posterior apex of the plate extends backwards between the inner margins of the centrals (*c*), a feature in which there is a notable difference from *Coccosteus*, though a similar arrangement is seen in the genus *Homosteus.**

The outline of the *centrals* (*c*) can be fully traced on one side. The median suture extending to the median occipital (*m. o.*) with its characteristic posterior sigma is very clearly defined.

The anterior margins, beginning, as stated, in front of the apex of the ethmoid, and the lateral margins, especially that on the right hand side, can be traced for their entire course.

The *median occipital* (*m. o.*) is large and has the usual sub-quadrate form characteristic of *Coccosteus.*

The *orbit* on the left side is retained and this helps to establish the outline of the *pre-orbital* plate (*p. o.*) on that side.

I have marked on the diagram as *pre-maxillary* (*p. mx.*) a fragment lying in front of the pre-orbital (*p. o.*), though it is not clearly separated from the *maxillary or infra-orbital* (*mx*) lying beneath or outside of the orbit. The plate marked (*x*) may also be a part of the maxillary (*mx*), for while it is separated from the latter by a deep sinus, it is difficult to decide whether this is a sensory canal or a true suture.

The left side of the specimen is covered by a broad expansion upon which evidences of sutures are very uncertain. This surface undoubtedly includes the *post-orbital* (*pt. o.*) and *marginal* (*m*) plates (the latter of which is fairly well defined on the right hand side of the specimen) and probably some portion of the *ventro-laterals* (*vz.*) The plates (marked *e. o.*) correspond in

* See Traquair's figure of *Homosteus*, loc. cit. pl. 1. fig. 1.

position to the *lateral occipitals* in *Coccosteus*, that on the right being much the more clearly defined.

The fragment of a plate lying behind the median occipital and at the right post-lateral extremity (marked *sc*), I take to be a *scapular* or *supra scapular*. Its inner extremity bears a ball-shaped condyle which may have articulated with the occipital at the post-lateral re-curvature where the margin of that plate appears to be entire.

Thus far the structure of this cranium evinces some relation to *Homosteus*, and no slight agreement with *Coccosteus;* still there are some conspicuous points of difference from the latter genus, notably in the relation of the ethmoid (*a. e.*, *pt. e.*) and central (*c*) plates. Whether species of the same genus may vary to such a degree in the structure, is a point which is referred to more expert fishermen.

The denticulate mandibles lying near the left ante-lateral margin of the shield will have a definite and important bearing upon this subject.

Here are the two branches of the lower jaw with an aspect highly similar to those of *Dinicthys*. The inner of the two (marked *man.* 1.) is rather the more complete, though its anterior termination is obscure and the posterior extremity somewhat indistinctly expanded. On this the row of short conical denticulations situated just in front of the narrowest part of the organ is very clear, but in the other specimen (*man.* 2.) the edge is broken along the margin, though the anterior extremity is distinctly defined and shows three relatively large cutting points, close together and beveled on their inner or proximal faces. Though this mandible appears to be somewhat shorter than the other I believe there is little reason to doubt the correctness of the interpretation here given of their structure. The exterior aspect of both mandibles is shown.

There seems to be some degree of uncertainty as to the structure of the mandibles in *Coccosteus* and *Homosteus*. Lydekker's restoration of *Coccosteus* gives a curved ramus with a tubercled surface but also without denticulations; in both respects unlike the specimen under consideration. Zittel speaks of the mandibles of *Coccosteus* as elongate bones with a few little teeth, and von Koenen describes a ventro-lateral rod-like and tubercled organ in *Coccosteus* (*Brachydirus*) of somewhat similar aspect to that represented as a mandible by Lydekker but regarded as a steering organ or the spine of a pectoral fin. Newberry makes a statement in regard to the mandible of *Coccosteus* which is more to the point. He says:* "It has been supposed that the dentition of *Coccosteus* and that of *Dinicthys* were radically different, but I have learned that they were very much alike. The mandibles of *Coccosteus* that have been figured are all imperfect, the anterior ends being crushed, distorted or wanting; yet, as I have mentioned elsewhere, I recently found in the South Kensington museum a mandible of *Coccosteus* which was a perfect miuiature of that of *Dinicthys*, being spatulate posteriorly and having the anterior end turned up to form a conspicuous denticle." This passage omits to state to which of the two types of *Dinicthys* mandible the specimen referred to conforms. Hugh Miller, in the fourth edition of "The Old Red Sandstone," after demonstrating in description and figure that the mandible of *Coccosteus* is denticulated, further showed (foot-note to page 52) that there is also a row of three to five teeth on each ramus along the vertical anterior median symphysis, and in later editions of this work a sketch was inserted illustrating this structure. The writer also had the opportunity some eleven years ago, while visiting the Hugh Miller collection in the Edinburgh Museum of Science and Art, of examining and making a drawing of a mandible labeled *Coccosteus*, in which the symphysial teeth are distinctly exhibited. I presume this is that figured by H. Miller. Claypole has also shown their existence in his species *C. Cuyahogœ*.†

In the Livonia specimens there is no evidence of this structure which appears to be normal to *Coccosteus*. The three stout terminal teeth are large and distinctly above the symphysis, as is very clearly shown in *man.* 2.

The resemblance to *Dinicthys* is in the form of the ramus and the presence of the row of conical denticles, to *D. Herzeri* and *D. intermedius*, Newberry, rather than to *D. Terrelli*, Newberry and *D. Newberryi*, Clarke, in which there are no denticles, but a long cutting edge.

* Palæozoic Fishes of North America, p. 143. † American Geologist, March, 1893, p. 169.

There are two small subtriangular bones, undoubtedly the intermaxillaries of the upper jaw, lying embedded in the rock at the points marked A and B. One of these (A) it has been possible to remove; the other is complicated with the extremity of the mandible (*man.* 1) in such a way as to render its removal without damage to the latter impossible. I have represented these two bones at the front of the diagram, in the relative position which they bear on the specimen. Each is concave on the inner surface, convex externally, and bore a somewhat extended inner apophysis, which in each case has been broken off. There is no evidence of denticles or a tubercled surface; the lower edge is, however, rather sharp and would have served a cutting purpose.

Dr. Newberry restored the cranial structure in *Dinicthys intermedius** and there are many points of similarity in the composition of the cranial plates as given by him and that seen in our specimen. While the characteristic triangular form of the cranium of *Dinicthys* is here absent and there is a palpably closer agreement in the cranial structure of *C.? halmodeus* and *C. decipiens*, still the former with its *Dinicthys* mandibles and intermaxillaries serves to demonstrate very forcibly the closeness of the relations existing between *Coccosteus* and *Dinicthys.*

This description may be closed with the account of a second specimen from the same horizon, in regard to the nature of which I have felt there is room for doubt. In its general external aspect and outline it is quite similar to the median and anterior portion of the cranium. Upon removing a portion of the plate on the right it appears that there are two well-defined and symmetrical lines on the inferior cast, which have the same relative position and extent as the median longitudinal pair of sensory canals of the cranium. That these, however, are not such canals, but sutures, I think is satisfactorily shown, not only by the sharp impressions they have left in the inner matrix, but also by the fact that in breaking off a portion of the plate the fracture stops sharply at this line and leaves a clean vertical surface transsecting the entire thickness of the bone. This pair of sutures divides the shield into three plates, one sublanceolate median, two broad undivided lateral plates. The median plate bears on its inner

*Op. cit., pl. lii., fig. 2.

surface a pronounced longitudinal crest, much thickened and considerably produced into the matrix at its anterior extremity. The general form of the entire shield taken in connection with the presence of the median crest would indicate that this is a *dorso-median* plate, in which case its position as represented upon Plate I, figure 2, is reversed. I am unable to give it any other construction or to explain the significance of its evident division into three parts.

Nautilus Hyatti, Hall.

Palæontology of New York, vol. v, pt. 2 (vol. vii, Suppl. p. 37, pl. 126, fig. 1).

The original of this species was described from the Hamilton rocks of Cumberland, Maryland, and has not before been elsewhere recognized. A portion of a body whorl from the Hamilton shales at 404 feet in the Shaft bears similar surface markings to *N. Hyatti*, that is, fine, sharply elevated and distant raised revolving lines crossed by frequent concentric lines which become obsolete near the aperture of the shell.

Orthoceras Geneva, sp. nov.

Plate II, figs. 5–7.

This is a fragment from the Corniferous limestone in the northern part of Geneva township, which seems to indicate a new representative of the annulated longitudinally striated orthocerata. The specimen has been compressed and this has given the annulations an unnatural obliquity. There are five of these preserved; they are broad, low, rounded and with shallow interspaces, and both annulations and furrows are crossed by longitudinal striæ which are rounded, threadlike and of equal size. Concentric striæ are exceedingly obscure. The character of this surface ornamentation is unlike that in the common annulated species of this fauna, *O. Thoas*, Hall, where the longitudial striæ alternate in size as they do also in the species *O. nuntium*, Hall, and *O. crotalum*, Hall, which have also been identified in the Corniferous limestone.*

Orthoceras fenestrulatum, sp. nov.

Plate II, figs. 10, 11.

This is a species with a rather broad stout tube, without annulations, but with a characteristic ornamentation that seems to

* Palæontology of New York, vol. v, pt. 2, p. 265.

distinguish it from other described forms. The surface bears two series of sharply elevated striæ of about equal size, though they vary somewhat among themselves. The concentric striæ are low, broad at the base, leaving rather narrow interspaces, while the vertical striæ are much more sharply elevated and broader, the interspaces being larger than between the members of the other series. The transverse striæ are of subequal size, there being slightly coarser ones at irregular intervals while the crossing striæ alternate regularly in size, forming in general two series. The course of the transverse striæ is not modified by the vertical striæ, while the latter are warped over the former and down into the interspaces, forming low nodes at the points of intersection. On the internal cast traces of the transverse striæ are more clearly retained and they leave rather broad depressions on the surface giving the cast an appearance suggesting the surface in the species *O. aulax* and *O. anguis*, Hall, *O. filosum*, Clarke, and the supposed pteropod shell *Pharetrella tenebrosa*, Hall, three species which may prove to be congeneric organisms.

The orginal specimen is from the Stafford limestone, at Stafford, Genesee county, N. Y.

Orthoceras Staffordensis, sp. nov.

Plate II, figs. 1, 2.

This is another of the annulated orthocerata in which the concentric rings are low, fine, irregularly distant and crossed by fine though sharply elevated, equidistant longitudinal striæ of two series. These and the interspaces are crossed by finer and very sharp imbricating concentric striæ which at their intersection with the former make low nodes, retrally inclined.

The original specimen, from the Stafford limestone of the Marcellus shales, at Stafford, Genesee county, has a length of 68 mm., a greatest diameter of 16 mm. and bears 44 annulations. This species differs from *O. nuntium* in the more numerous and less regular annulations; from *O. Idmon* in the same manner and its more regular, rather coarser longitudinal striæ and sharp concentric lines; from *O. celamen* and *O. Lima* in the character of the surface sculpture.

Orthoceras nuntioides, sp. nov.

Plate II, figs. 8, 9.

A strongly annulated shell of the type of *Orthoceras nuntium*, *O. crotalum*, etc., possessing the same style of external ornamentation, but the longitudinal elevated striæ are much finer than in any species heretofore described. These striæ are of subequal size and are closely crowded, the appearance of fine intercalary striæ being infrequent. Very faint concentric striations are visible on certain portions of the surface. The original specimen retains nine strong, distant annulations, which are more conspicuous than in *O. nuntium;* and also the apertural extremity of the shell, upon which no annulations exist. The specimen is from the calcareous Marcellus shales in the village of Chapinville, Ontario county.

Orthoceras profundum, Hall

Palæontology of New York, vol. v, pt. 2, p. 271, pl. 37, pgs. 7–9.

This species, we believe, has not heretofore been recognized except in the faunas from which it was originally described, the Corniferous limestone, but a very characteristic example has been taken from the lower limestone of the Marcellus shales at 854 feet in the Shaft, where it is associated with other Corniferous species, *Chonetes lineata*, *Cœlospira Camilla*, *etc.*

Orthoceras incarceratum, sp. nov.

Plate II, figs. 3, 4.

Tube with numerous subequidistant, broad and low annulations, which are crossed by fine sharp concentric elevated striæ. These are traversed by very fine, straight, longitudinal striæ of about the same size, and the intersection of the two series covers the surface with minute fenestrules measuring about 2 mm. on the edge. These spaces are traversed by exceedingly fine concentric lines, visible only under considerable magnification. The striæ are equally developed on annulations and interspaces, and their intersections are elevated into low nodes or points which are visible when the lines are abraded. One of the specimens referred to the species, has the transverse lines highly developed while the series of vertical lines is very obscure.

Of two specimens of this *Orthoceras* one has 12 annulations in a length of 28 mm., the other has the same number in a length of 40 mm.

Both are from the limestone layer in the Marcellus shales at 854 feet in the Shaft.

Orthoceras Œdipus, Hall.

Plate II, fig. 12.

Palæontology of New York, vol. v, pt. 2, p. 294, pl. 37, fig. 6.
pl. 82, fig. 17.

This species, which is very abundant in the Hamilton shales from 473 to 488 feet in the Shaft, was described from specimens whose exterior was very imperfectly preserved. An enlargement of the outer ornamentation is therefore given here from a very perfectly preserved example. The sculpture consists of a series of longitudinal ridges of variable size, those of the first order being only approximately equidistant and the intervals filled by ridges of two or three lesser sizes, at unequal intervals. All are crossed by very sharp, closely-set concentric striæ, which make a slight node at their junction.

Gomphoceras mitriformis, sp. nov.

Plate III, fig. 1.

The specimens upon which this species is based is an individual which lacks the apex only, but has been compressed in the shales, without distortion of outline. It is a quite symmetrical shell, widening from a moderately broad aperture and attaining its greatest diameter at a point just posterior to the middle of its length, whence it tapers rapidly, with a convex curve for a portion of the distance, and concave margins posteriorly, to a very narrow if not acute inception. The entire length of the specimen is 135 mm.; its width at the aperture, 40 mm.; its width at a distance of 60 mm. from the aperture, 51 mm. The external surface is smooth and so preserved as to show but little evidence of septa, the first of these being at a distance of 39 mm. from the aperture. The apical portion of the shell retains traces of the siphuncular beads, 13 of these being exhibited in a distance of 18 mm., showing the very close approximation of the septa in this part of the shell.

The species is less robust and more graceful than *G. Fischeri*, Hall, of the Goniatite limestone, differing in its marginal curvature and general proportions from this as well as other described members of the genus.

From the calcareous beds of the Marcellus shales at Chapinville, Ontario county, N. Y.

Hyolithus ceratophilus, sp. nov.

Plate IV, figs. 17, 18.

The genus *Hyolithus* was one of great rarity in limestone faunas of the Upper Helderberg group. Indeed, as we know of the occurrence of but a single form of these limestones, the discovery of a species of quite commanding proportions in this fauna is worthy of record. A specimen was sent to the museum in January, 1892, by Dr. D. F. Lincoln, of Geneva, N. Y., which was taken from the lower part of the Corniferous limestone in the northern part of that township.

The apical portion of the shell is wanting, but, where entire, the original length was not less than 70 mm., while the transverse diameter at the aperture is 20 mm. The ventral or flat side of the shell is produced at the aperture, where its outline is broadly convex, and the dorsal side is subangular medially with sloping flattened sides. The ornamentation consists of longitudinal lines, strongly elevated on the dorsal side, where the alternation in size is very apparent. On the opposite side the longitudinal lines are fainter, and are crossed by concentric growth lines which are not distinct outwardly.

Hyolithus ligea, Hall, which occurs not infrequently in the Schoharie grit, and has been reported in a single instance from the limestone at Clarence, N. Y., is a much smaller shell with distinct contour and surface markings, and a similar difference is apparent between *H. ceratophilus* and *H. principalis*, Hall, of the Schoharie grit, the latter a species of still larger proportions than the former.

Onychochilus nitidulus, sp. nov.

Plate IV, figs. 13–16.

In a list of the fossils known to occur in the Marcellus division of the Hamilton series, published in the Eighth Annual Report of the New York State Geologist,* reference was made to a sinistrally coiled gastropod, under the generic term *Scævogyra.* The name was introduced by Whitfield in 1878,† for sinistral shells from the Lower Magnesian limestone of Wisconsin, which bear resemblance to *Maclurea*, but the spire is, in the typical species, considerably elevated, though the shell is deeply umbilicated. Mr. Whitfield regarded these fossils as probably heteropodous. Closer examination of the specimens from the Marcellus demonstrates that they are of quite different nature than *Scævogyra*, and afford an interesting instance of reversed coiling in the palæozoic pyramidellids.

The shells are very small, and are not associated with dextrally coiled species of similar structure in any other respects. All the whorls are sinistral, are regularly rounded on their upper surface, slightly carinated on the periphery and less convex below. The angle of the apex is about 45°. The stoma is oval, and the shell non-umbilicated. Surface covered with low and very faint concentric growth lines.

DeKoninck described from the Carboniferous limestone of Belgium, certain reversed species under the name *Agnesia*, and these have been regarded by Holzapfel as essentially sinistrally coiled forms of *Euomphalus*, though the latter author has found the group not homogeneous and has separated from it some of the species described by DeKoninck, proposing for them the name *Hesperiella*. *Hesperiella*, as suggested by Dr. Holzapfel, is a genus of reversed *Pleurotomaridæ*.

The form under consideration is a holostomatous shell, in effect a reversed *Macrochilina*, and it is provisionally referred to Lindström's genus *Onychochilus*.

It was obtained from the Stafford limestone of the Marcellus division at Stafford, Genesee county; a rock which contains a rich and nearly normal Hamilton fauna, and which appears in the Livonia shaft section at a depth of 823 feet.

Nuculites subcuneatus, sp. nov.

Plate IV, figs. 9, 10.

Shells oblique, subtrihedral in contour, transversely oval in marginal outline. The beaks are incurved, directed anteriorly and

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* 1889, page 61.

† Ann. Rep't. Geol. Surv. Wisconsin, for 1877, p. 61; and Geology of Wisconsin, vol. iv, p. 196, pl. 3, figs. 7-11, 1882.

situated at the anterior one-fifth of the transverse diameter. The anterior margin is narrowly convex, rounding abruptly to the ventral margin which is broadly curved to the subacute posterior extremity. On the posterior margin the slope is obliquely forward, and a large angle is formed at the union of the posterior and dorsal margins. The umbones are broadly flattened, and this flattened area widens over the pallial region of the valves. Posteriorly it is sharply delimited by the umbonal ridge, from which the slope is slightly concave to the posterior margin. A well-defined clavicular ridge extends from the anterior edge of the beak with a slight inward curve, two-thirds of the distance to the ventral margin. Surface covered with fine concentric striæ. Length of average specimens, 20 mm.; height, 13 mm.; greatest transverse diameter, 21 mm.

This shell is intermediate in its contour and outline between the elongate, posteriorly acuminate *N. cuneiformis*, Conrad, and the shorter more sharply angled *N. triqueter*, Conrad. It is, however, persistent in the features described, and is not of infrequent occurrence in the Hamilton shales at from 447 to 463 feet in the Shaft. The specimens figured are from a depth of 450 feet.

Lucina (?) Livonensis, sp. nov.

Plate IV, fig. 1.

This is a rather small, subcircular shell which has the outline and essentially the external expression of the common species in the Naples shales described originally as *Ungulina suborbicularis*, but which has been variously referred since, while its generic characters still await elucidation. Such forms, however, have been so rarely, if ever, observed in faunas antedating the extinction of the normal fauna of the Hamilton shales that the occurrence of one in the Marcellus shales (at a depth in the Shaft of 820 feet) prompts a notice of it.

The beak is scarcely prominent, is situated in front of the middle of the valve, hence the posterior dorsal slope is longer than the anterior. The surface is evenly convex and is smooth though bearing low, concentric wrinkles, which are most prominent about the umbo. These are crossed by faint, distant incised radiating striæ.

While similar in outline to some forms now referred to *Panenka*, it is quite evident from the data supplied by the Portage species referred to, that such shells as these must be separated not only from *Panenka* but also from the Devonian *Paracas*, *Cardiolas* and *Glyptocardias.* It is, therefore, provisionally referred to the old genus *Lucina*, although it is quite certain that the reference is not exact.

In the lithographic figure the cardinal slopes are much too sharp and direct, giving the shell an unnatural resemblance to a *Lunulicardium.*

Lunulicardium Livoniæ, sp. nov.

Plate IV, fig. 11.

Shell represented by a left valve, which is of small size and has the normal proportions of *L. ornatum*, Hall, of the Naples shales. It is, however, much more finely ribbed, the surface bearing about 60 plications, which are mostly simple, but a few showing signs of duplication toward the margin. In *L. ornatum* the number of plications in normal adults is rarely over 50, and correspondingly less in immature shells.

The valve measures 18 mm. in length and 15 mm. in greatest transverse diameter.

From the dark Hamilton shales at 570 feet in the Shaft.

Lunulicardium (??) lineolatum, sp. nov.

Plate III, fig. 2.

Shell small, with sharply sloping cardinal margins, diverging from the apex at an angle of 135°; periphery subcircular; apex slightly incurved, surface evenly convex. Anterior cardinal line straight and sharply defined; posterior cardinal slope less abrupt, quite convex and incurved. (This feature is not satisfactorily represented in the figure.) Surface covered with low concentric wrinkles or rounded striæ, and these are crossed by a series of fine, sharp, radial, elevated lines, which are most numerous and best defined in the umbonal region, comparatively few extending to the margins of the valve. The shell has a corneous appearance, and it is probable that there is but little calcareous matter in its composition. The species is provisionally referred to the genus *Lunulicardium*, in full realization of the fact that it is not a member of this genus, from which, when better understood and more precisely restricted, many heterogeneous forms now passing under this name must be excluded. The left valve described has a height and length of 10 mm. Upper Hamilton shales. At 225–350 feet in the Livonia Shaft.

Orthothetes bellulus, sp. nov.

Plate IV, figs. 2–4.

This very pretty species is of persistently small size and quite regular in form, none of the specimens showing umbonal distortion. The valves are transversely elongate, the hinge-line forming the greatest diameter; and subequally convex. The surface is covered by eighteen or twenty sharp, narrow, distant plications, extending from the margin almost, if not quite, to the apex, and in the middle of each of the broad interspaces is a smaller and usually very obscure rib; rarely two of these ribs are present. These two series only are to be seen. The lower half of the surface is crossed by sharply imbricating concentric striæ, which are visible only on the interspaces. On the interior the characteristic processes of this genus are found.

The length of an average specimen is 10 mm.; its diameter along the hinge, 15 mm.

This is from the limestone of the Marcellus division at 854 feet in the Shaft, and has not been elsewhere observed. It is there associated with specimens of *Orthothetes arctostriata* of small size, finely, subequally plicated and often distorted, but there is little indication of any specific connection between these two shells.

Chonostrophia reversa, Whitfield (sp.).

Plate IV, fig. 5.

Among the specimens sent by Dr. Lincoln, of Geneva, is a small fragment of the dark limestone quarried at Union Springs, N. Y., which contains a number of valves of this species; the first, I believe, that have been recorded from this State. These are all of inferior size to those found at Delaware, Ohio, the original locality, as well as to those occurring in the blocks of decomposed chert about DeCewville and Cayuga, Province of Ontario.

Ambocœlia spinosa, sp. nov.

Plate IV, figs. 6–8.

Shell of rather large size, hinge-line straight equalling the full diameter of the valve. Brachial valve depressed-convex in the umbonal region, concave anteriorly with upturned margins. Medially there is a low and indistinct elevation which disappears toward the front. Pedicle-valve not known. Surface bearing faint traces of concentric lines and covered with numerous elongate depressions which were probably bases of insertion of epidermal spinules.

Length of the original specimen, 7 mm.; width on the hinge, 9 mm.

Hamilton shales. At about 300 *feet in the Livonia Shaft.*

Hyalostelia (?) Marcellia, sp. nov.

Plate IV, figs. 19–22.

In the Marcellus shales, at a depth in the Shaft of 812 to 823 feet, there were found in considerable abundance, broad, thin, film-like expansions tinging the rock surface, from pyritization, a greenish or yellowish hue, but having no definite limits, making irregular splotches of discoloration. When magnified these patches are seen to be composed of masses of minute rod-like and often cruciform sponge spicules, changed to pyrite. The cruciform spicules are evidently hexactinellid as many of them which exhibit but four branches on the same plane show the bases of the other two rising in the plane at right angles; in some, however, there seems to be no evidence of more than four rays. With these spicules are found larger and coarser spicular bands, flat, straight, thickened on the edges or in the middle, and not at all unlike small blades of grass. These end abruptly at one end but taper to the other, though showing no evidence of terminating in any appliance for attachment.

There is no evidence whatever that these broad ribbon-like spicular strands are composed of separate spicular rods, but, on the contrary, they are clearly distinct and simple bodies. Their association with the cruciform spicules is so close and invariable as to enforce the organic connection of the two; and yet we are at a loss to interpret their meaning as, to our knowledge, there has been no similar structure observed among the hexactinellids.

It is impossible to gain a conception of the form of the sponge to which these masses of spicules belong, but the discovery is nevertheless an interesting one, as such an organism is new to these rocks. In the absence of essential generic characters except as evinced by the large flat bands, the fossils are provisionally referred to the genus *Hyalostelia*, Zittel.

Genus Ceratostigma, nov.

Ceratostigma papillata, sp. nov.

Plate III, figs. 3–7.

The calcareous shales of the Hamilton group at 450 and 460 feet in the Shaft furnished a few fragments of stipes or flattened branches of some length, whose surface is covered with somewhat irregularly arranged, smooth mammiform tubercles, each bearing a central pit. The general aspect of these bodies together with their black, carbonaceous substance led to a first impression, after a cursory examination, that they were of vegetable nature. The papillæ of the surface suggested the exterior of *Cyclostigma*, while it seemed possible that the irregularity in the arrangement of these papillæ might be paralleled by the structure of the roots of this or allied plants of the Devonian.

The novel appearance of the specimens led me to seek the opinion of Sir Wm. Dawson as to their nature, and it is in pursuance of the suggestions expressed by him, after an examination of the fossils, that some account of their structure and investigation of their affinities is here given.

Concerning these bodies Sir William wrote under date of January 1, 1892: "They are quite new to me, and I somewhat doubt their vegetable nature. The pustules on the surface are not regularly arranged, nor of one size, and do not seem to be seals or articulations of leaves or roots, but rather round papillæ with central pores. When sliced and magnified they show a thin, finely granular carbonaceous film with calcareous matter in a crystalline state within. In some places the calcite shows traces of spicules. I should be inclined to compare the specimens with encrusting or branching Alcyonoid or Actinoid polyps." At a later date Sir William again wrote, communicating the opinion of Prof. D. P. Penhallow, to whom he had submitted the specimens, that they are not of vegetable nature.

The surface characters of these bodies will be best understood by consulting the figures of them given upon plate III. The best preserved of the specimens has a length of 65 mm. and an average width of 7 mm.; and all the examples have about the same width. They are all flattened, showing a similar surface on both sides, and a central filling of matrix, and were, therefore, undoubtedly cylindrical and hollow bodies. The surface is closely covered with the tubercles or papillæ, which are sometimes evenly convex, sloping equally in all directions, but as a rule are elongated longitudinally at their bases, as though resting on ridges which are frequently interrupted or contracted from close apposition to, or encroachment by adjoining ridges. Often they have a lachrymiform appearance caused by the abrupt termination at one side, of the ridges upon which they rest. The center of the upper surface of each pustule bears a small circular pit, which, though shallow, is deep enough to penetrate the tenuous coatings of the fossil, and which is, from the evidence afforded by the fossil itself and by a sharp external cast, quite smooth, without trace of radial markings or septa.

The structure of the fossil, as far as possible to determine, is the following: The fronds or zoaria are flat, thin, narrow and tape-like. Frequently in the specimens there is a very minute interval between the two sides, the space between showing no trace of matrix; one of the specimens, however, clearly demonstrates the existence of an internal tubular cavity, and, inferentially, the subcylindical form of the bodies. In a stipe 10 mm. in diameter, the thickness of the wall of the fossil is not more than .5 or .3 mm. The outermost lamina of the wall is an extremely tenuous coating of chitinous matter which is striated by very fine, subparallel longitudinal lines (see plate III, fig. 1), which are more or less interrupted throughout their extent. This outer coating seems to be easily destructible, and in the largest example (that represented in figs. 3, 4 and 6) is not retained. Beneath this outside layer is a thicker wall constituted of an outer portion of calcite completely crystallized into rhombohedrons, and an inner portion of black bituminous matter. The crystallization of the calcite appears to have disordered to some degree the usual arrangement of the solid tissues, and in sections the organic or chitinous substance is seen to be moulded about the minute calcites in such a way that the determination of which is really the innermost of the layers is not easy. Certain specimens show, however, with a fair degree of certainty that the calcareous layer lies between the two layers of chitinous matter, and it is fair to infer that the crystalline character of this middle layer is due wholly to changes concomitant with, or subsequent to fossilization.

The substance of the walls is considerably increased in thickness beneath the papillæ and this appears to be due largely if not wholly to an increase in the thickness of the calcareous layer.

Micro-sections give no satisfactory evidence of spicules, but their absence may be explained by the changes to which the calcareous layer of the wall has been subjected. From what can thus be learned of these fossils there is good reason to believe that Sir William Dawson's suggestion of their alcyonarian character is the correct one. In exterior they resemble the living Gorgonias, *Plexaurioides*, *Lophogorgia*, and *Scirpearella*, and if the interior differs from the known structure of any living Gorgonia in the great axial canal and the arrangement of its component walls it is not a difference incompatible with its variations occurring in this respect among the Gorgonidæ. We thus, probably, have represented in these fossils the earliest known forms of this family.

EXPLANATION OF PLATES.

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PLATE I.

Coccosteus? halmodeus, sp. nov.

Fig. 1.— The dorsal aspect of the specimen described, showing what is retained of the cranium and mandibles. The distinction between the sensory canals and sutures will be best elucidated by comparison with the diagram given upon page 162.

Fig. 2.— A plate believed to be a dorso-median shield of the same species. If this is the correct interpretation of its nature, it has been drawn in a reversed position. The plate is considerably broken and in such a manner as to demonstrate the presence of a strong internal median ridge, which is deepest at the anterior (posterior) extremity. The surface shows no satisfactory evidence of sutures.

Marcellus shales. At 825–828 *feet in the Livonia shaft.*

PLATE II.

Orthoceras Staffordensis, sp. nov.

Fig. 1.— Natural size view of the original specimen.

Fig. 2.— An enlargement of the surface ornamentation. ×5.

Stafford limestone of the Marcellus shales. Stafford, N. Y.

Orthoceras incarceratum, sp. nov.

Fig. 3.— The original specimen, showing the approximate annulations and the fine concentric and longitudinal ornamentation.

Fig. 4.— An enlargement of the surface, showing the external markings in more detail. ×5.

Lower limestone of the Marcellus shales at 854 *feet in the Livonia shaft.*

Orthoceras Geneva, sp. nov.

Fig. 5.— An enlargement of the exterior, showing the equidistant and subequal longitudinal striæ and the finer, much more closely set concentric lines. ×5.

Figs. 6, 7.— Opposite sides of the original specimen.

Corniferous limestone. Geneva, N. Y.

Orthoceras nuntioides, sp. nov.

Fig. 8.— A view of the typical specimen, in which the vertical surface lines have not been made sufficiently fine.

Fig. 9.— An enlargement of the exterior. ×5.

Marcellus shales. Chapinville, N. Y.

Orthoceras fenestrulatum, sp. nov.

Fig. 10.—An internal cast with a small portion of the shell attached, showing the non-annulated form and the surface characters within and without.

FIG. 11.— An enlargement of a portion of the exterior, showing the character of the striæ. × 5.

Stafford limestone of the Marcellus shales. Stafford, N. Y.

Orthoceras Œdipus, Hall

FIG. 12.— An enlargement of the external surface. × 5.

Hamilton shales, at 473 *feet in the Livonia shaft*

PLATE III.

Gomphoceras mitriformis, sp. nov.

Fig. 1.—The original specimen, which is in a somewhat macerated condition, but its outline is apparently entire and undisturbed.

Marcellus shales. Chapinville, N. Y.

Lunulicardium ? lineolatum, sp. nov.

Fig. 2.—A left valve enlarged to three diameters, showing the sharp elevated radial lines covering the concentric lines of growth. The posterior extension of the hinge has been represented as too straight and abrupt, there actually being in this portion of the cardinal region a convex curvature of the valve to the hinge.

Upper layers of the Hamilton shales, between 225 *and* 350 *feet in the Livonia shaft.*

Ceratostigma papillata, sp. nov.

Fig. 3.—A natural size view of the longest specimen.

Fig. 4.— The same enlarged to three diameters to show the structure of the surface. On parts ofthis specimen the thin layer of the substance of the fossil has been removed and exposes an impression of the inner side. The outermost chitinous coat of the species is not here preserved.

Fig. 5.— An external cast of a portion of a zoary enlarged to five diameters.

FIG. 6.— An enlargement of a portion of the specimens represented in figures 3 and 4. × 5.

FIG. 7.— A portion of a specimen retaining the striated external chitinous coat. × 5.

Hamilton shales, at 450 *and* 460 *feet in the Livonia shaft.*

PLATE IV.

Dignomia alveata, Hall.

Fig. 1.— A specimen showing both valves, but very poorly lithographed. The purpose of this illustration was to elucidate a structural feature in this genus which has not before been well understood. In the specimen the valve at the left lies beneath the other and has been exposed by the breaking away of the filling of the latter. The valve at the right is evidently, from the greater prolongation of the apex (not shown in the figure), the pedicle-valve, and its internal ridges have been exposed by the removal, through weathering, of the principal part of the substance of the valve. In the other valve the internal surface is exposed. The specimen shows that the diverging umbonal ridges are about equally developed in both valves and when the valves were in their normal position the ridges of one must have been situated within those of the other, and thus probably have formed a rudimentary articulation. The median septa of the two valves differ and afford a means of distinguishing the two when found separately. That of the brachial valve is a sharply elevated and narrow ridge, while that of the opposite valve is broad, flat and scarcely elevated.

Upper Hamilton shales, between 225 *and* 350 *feet in the Livonia shaft.*

Orthothetes bellulus, sp. nov.

Fig. 2.— An internal cast of the brachial-valve.

Fig. 3.— The pedicle-valve.

Fig. 4.— An enlargement of portion of the surface.

Lower limestone in the Marcellus shales, at 854 *feet in the Livonia shaft.*

Chonostrophia reversa, Whitfield (sp.).

Fig. 5.— Exterior of a pedicle-valve with convex umbo and flat or slightly concave anterior surface. ×3.

Corniferous limestone, Union Springs, N. Y.

Ambocœlia spinosa, sp. nov.

Figs. 6, 7.— The exterior and interior of a brachial valve. ×2.

Fig. 8.— A portion of the exterior enlarged, showing the elongate impressions on the surface, which appear to be bases of spines.

Hamilton shales, between 225 *to* 350 *feet in the Livonia shaft.*

Nuculites subcuneatus, sp. nov.

Figs. 9, 10.— Right and left valves; natural size.

Hamilton shales; at 456 *feet in the Livonia shaft.*

Lunulicardium Livoniæ, sp. nov.

Fig. 11.— Left valve, showing the form and character of surface.

Dark shales of the Hamilton group, at 570 *feet in the Livonia shaft.*

Lucina (?) Livonensis, sp. nov.

Fig. 12.— The exterior of a left valve in which the radiating lines are represented rather too sharp and the posterior cardinal slope too long and straight.

Marcellus shales, at 820 *feet in the Livonia shaft.*

Onychochilus nitidulus, sp. nov.

Figs. 13, 14, 15.— Three views of a specimen, showing the form of the shell and the sinistral whorls. ×10.

Fig. 16.— View of a specimen with a somewhat angular body-whorl, but represented as quite too sharply carinate. ×10.

Stafford limestone (Marcellus group), Stafford, N. Y.

Hyolithus ceratophilus, sp. nov.

Figs. 17, 18.—Ventral and dorsal sides of the type-specimen.

Corniferous limestone, near Geneva, N. Y.

Hyalostelia (?) Marcellia, sp. nov.

Fig. 19.— An enlargement of a portion of rock surface, showing the cruciform, rod-shaped and strand-like spicules. ×5.

Fig. 20.— A larger surface less enlarged. ×2.

Fig. 21.— A spicule viewed from the interior surface and showing the broken end of the axial ray. ×16.

Fig. 22.— A still further enlargement of a spicule, showing the outer surface and the node to which one branch of the axial ray is reduced.

Marcellus shales, from 812 *to* 823 *feet in the Livonia shaft*

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

JAMES HALL, STATE GEOLOGIST.

1892-1893.

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GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

1892—1893.

In the report of 1892, published 1893, under the head of geological map, the writer has given a short resumé, pp. 25–39, of the history and progress of geological maps of the State and portions of the State, to the year 1888, those of subsequent date having been accidentally omitted. At the time of this writing it was intended to follow with the publication of the paper on the limestones of the Helderberg mountains and associated formations, and one other contribution to the geological map of the State. It became necessary, however, to postpone these papers to the report of 1893. The accompanying titles indicate the direction in which work has been carried on toward the completion of the geological map of the State up to the close of the season of 1893.

In 1892 the Legislature of the State made appropriations sufficient to secure the engraving of a base map, which was accomplished under the supervision of the United States Geological Survey. From this appropriation a small sum was reserved for field work, and a sum of $200 was also reserved for the mounting of one hundred copies of a preliminary geological map, which it was proposed, by Major Powell, to print in colors for the use of the State of New York. The Directors of the United States Geological Survey also assigned Mr. N. H. Darton, one of the assistants of that survey, to work under my direction in the State of New York, we paying only his field expenses, and his work has been continued for the seasons of 1892 and 1893.

The results of Mr. Darton's work will be found in the report upon the Helderberg limestones and associated formations of eastern New York; the distribution of the geological formations of the Mohawk valley; the geology of Albany and Ulster counties. The two latter have been supplemented by the work of Prof. Frank L. Nason, in the reports upon the economic geology of these two counties.

It has been the wish of the State Geologist to publish county maps giving the geological structure and distribution of the several formations, and accompany the same by maps showing the occurrence and distribution of the economic products of each one of the counties.

Prof. J. F. Kemp of Columbia College, New York, kindly volunteered to give his time to working up the geology of some portions of Essex county. Prof. C. H. Smyth, Jr., of Hamilton College, in like manner agreed to work out the relations of the Huronian or crystalline limestones, granites, etc., of Jefferson and St. Lawrence counties in their relations to the Laurentian rocks on the east. Prof. Cushing of Adelbert College, who had been working with Prof. Kemp, carried on his observations through a portion of Clinton county. To these gentlemen field expenses only were paid from the appropriation made by the State.

Dr. F. A. Randall was employed in working out the geological relations of the rocks of Chautauqua and Cattaraugus counties to the coal measures of Pennsylvania.

Prof. J. M. Clarke, assistant palæontologist, has spent several weeks in the field in Chenango county, with the purpose of tracing the western extension of the Oneonta sandstone and its gradual changes as it merges into the Portage group.

The reports of these gentlemen are herewith included in the report of the State Geologist for 1893, transmitted to the Governor and the Legislature in February, 1894.

The undersigned wishes to express his obligations to every one of the gentlemen named, who have rendered their services for the advancement of the geological map of the State. At the same time he desires to say, that for the statement of facts, observations, inferences and conclusions expressed in these reports, the authors are individually and solely responsible.

JAMES HALL,
State Geologist.

LIST OF GEOLOGICAL REPORTS.

Report on the Relations of the Helderberg Limestones and Associated Formations in Eastern New York;

By N. H. Darton.

Preliminary Report on the Geology of Albany County;

By N. H. Darton.

Economic Geology of Albany County;

By F. L. Nason.

Preliminary Report on the Geology of Ulster County;

By N. H. Darton.

Economic Geology of Ulster County;

By F. L. Nason.

Geology of the Mohawk Valley in Herkimer, Fulton, Montgomery and Saratoga Counties;

By N. H. Darton.

Preliminary Report on the Geology of Essex County;

By J. F. Kemp.

Preliminary Report on the Geology of Clinton County;

By H. P. Cushing.

Report on a Preliminary Examination of the General and Economic Geology of four Townships in St. Lawrence and Jefferson Counties;

By C. H. Smyth, Jr.

Report on the Geology of Cattaraugus and Chautauqua Counties;

By F. A. Randall.

Report on Field-work in Chenango County;

By J. M. Clarke.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

REPORT ON THE RELATIONS
OF THE
Helderberg Limestones and Associated Formations
IN EASTERN NEW YORK.

JAMES HALL, State Geologist. N. H. DARTON, Assistant.

1892.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Report on the Relations of the Helderberg Limestones and Associated Formations in Eastern New York.

By N. H. DARTON.

1892.

INTRODUCTORY.

JAMES HALL, *State Geologist:*

SIR.—In the autumn of 1892 I was assigned by Major Powell, Director of the United States Geological Survey, to field work in the State of New York under the direction of the State Geologist. This work was especially undertaken for the purpose of tracing accurately the limits of the several formations, with a view of affording data for the new geological map of the State now in course of publication.

The structure of the country to which I was assigned was already known from the geological survey of 1836 to 1842, but that work having been laid down upon unreliable maps it became necessary to go over the ground with more accurate maps in hand for the purpose of fixing the boundary lines of each formation.

During the months of September and October I was occupied with this work, my observations extending from Ellenville, in Ulster county, to the Niagara river, but detailed examinations were confined to the country east and south of Howe's Cave and Schoharie creek. To this region I devoted about one month of field work, being for the greater part of the time accompanied by the State Geologist. This report is a description of the results.

The stratigraphy and the general relations of the formations about Schoharie and the Helderberg mountains are already well known through the geological and palæontological reports of the New York Survey, and in these regions about all I have to offer as new are the details of distribution shown on the map and some measurements of thickness and dip. For the relations of the Helderberg formation in the folded region which was found to extend from the Helderberg mountains southward to the Shawangunk mountains, there are no reliable data on record, excepting for an area just west of Catskill and another about Rondout which were worked out in great detail by Professor W. M. Davis.* The complicated structure of the very important cement region about Rosendale and the interesting relations on the wide northern end of Shawangunk mountains have never before been fully described.

Physiography.

The region occupied by the Helderberg and associated formations in eastern New York presents a considerable variety of physical features closely related to the rocks and their structure, so that a brief consideration of the physiography will aid in the elucidation of the geology. The principal features in which we are concerned are the great Helderberg escarpment, the series of parallel ridges of Appalachian type to which it gives place from Albany county southward, and the great Shawangunk mountain into which these ridges merge in central Ulster county. To the south of the escarpment and west of the series of ridges and the Shawangunk mountain are the high hills and elevated terrace of the Hamilton formation. To the north and east are the steep slopes ending in the wide terrace of the Mohawk and Hudson, excepting south of Rondout where the terrace gives place to a rolling region of Hudson slates and sandstones.

The Helderberg escarpment is the precipitous face of an elevated, evenly-crested shelf, which extends from west to east

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*The Little Mountains east of the Catskills, Appalachia, vol. 3, pp. 20–33, pl. 1. 1882. The folded Helderberg limestones east of the Catskills, Harvard Coll. Mus. Comp. Zool., Bull. vol. 7, dp. 311-329, pls. 12, 13. 1883. The Nonconformity at Rondout, N. Y. Am. Jour. Sci. (3d series), vol. 26, pp. 389–395. 1883.

through the State and turns abruptly southward in Albany county at the edge of the Hudson basin in a great escarpment, constituting the eastern face of the Helderberg mountains. For the greater part of its course this shelf slopes back for several miles to the base of high hills, which consist of the lower members of the Hamilton group. The escarpment at the outer edge of the shelf consists of north-facing cliffs of limestone. In the Cobleskill and Schoharie region it is deeply trenched by the Cobleskill and Schoharie creeks, which flow out from the south and give rise to deep indentations on the line of escarpment. Figures 4 and 5 will illustrate the general structure of the eastern extension of the Helderberg escarpment, fig. 4 showing the cliffs and slopes on the west side of the gorge cut by Schoharie creek. Eastward from Schoharie for some miles the escarpment is a low line of cliffs varying from ten to one hundred feet in height, but averaging about fifty feet, and surmounting a long, broken slope of Hudson slates. The shelf extends from the crest of this cliff in a long slope southward to the Foxkill, a branch of the Schoharie creek, south of which rises the very high terraced hills of the Hamilton rocks. (See fig. 5.) Southeast of Altamont the escarpment attains its maximum prominence and constitutes the northern end of the Helderberg mountains. Here it presents imposing cliffs surmounting a rocky slope rising precipitously from 500 to 600 feet above the great plain which extends far to the north and east. A short distance behind the crest of the cliffs there rises a series of steep terraces, culminating finally in high hills of Hamilton rocks, all of which fall into the general slope as the line of cliffs trends southward, and culminating in a magnificent terraced escarpment rising steeply to an altitude of more than 1,200 feet above the plain.

In the next few miles to the eastward this escarpment gradually decreases in prominence, the members of the lower terraces widening out to the southeastward into a rolling region of moderate height and the Hamilton hills dropping back to the south and then extending to the southeast as a series of high north-trending ridges, ending abruptly northward *en echelon*.

The irregular eastern border of the rolling region in which the lower terraces merge is marked by a low, but distinct, escarpment of limestone cliffs separating it from the Hudson terraces, which lie about 200 feet below and extend eastward to the river. This escarpment extends for many miles southward at the eastern edge of the Helderberg formation, although it is sometimes buried by overlapping drift hills and it is frequently broken through by streams.

In the southern part of Albany county the rolling area above referred to gives place to the ridges of Appalachian type, which extend southward through Greene and Ulster counties in a narrow belt between the high hills of Hamilton. The physiography of this belt is fully illustrated in plates 3, 4 and 6, excepting for short distances about Catskill and Rondout, where the same features prevail.

South of Rosendale the ridges merge into the slopes of the Shawangunk mountain, which rises rapidly and attains great prominence. Its characteristics are the wide corrugated western slope, its great precipices facing eastward, its partially inclosed high hill areas of slate notably southeast of Ellenville and northwest of New Paltz, and its elevated cliff-encircled lakes, of which Mohonk and Minnewaska are the best known.

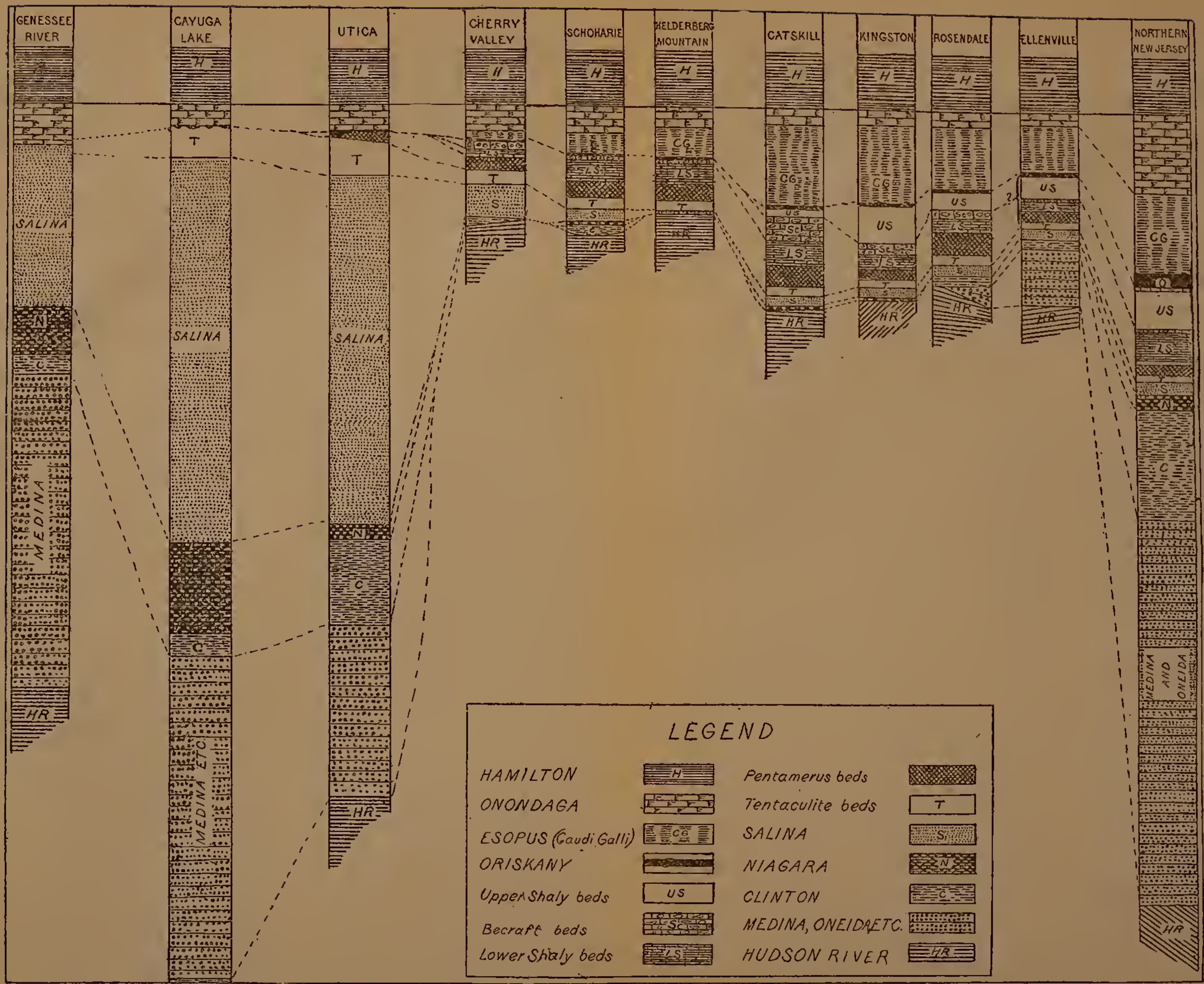
Stratigraphy.

General Relations.—In the reports of Hall, Vanuxem and Mather, the agriculture by Emmons, and papers by W. M. Davis and others, there are more or less extended descriptions of the several formations to which this report relates, and in greater part their general relations have been well known for over half a century. In the course of my examination of the region, however, many local details of character, distribution, overlap and thickness not heretofore described have been noted, and these are presented in this chapter as part of a systematized resumé of the stratigraphy.

In plate 1 I have given a series of columnar sections illustrating the general stratigraphic variations of the formations between the Hamilton and Hudson River shales throughout New York and to northwestern New Jersey. The first three are based mainly on well boring records described by Prosser* and Ash-

*The thickness of the Devonian and Silurian rocks of western central New York. Am. Geologist, vol. 6, pp. 199-211. 1890. The thickness of the Devonian and Silurian rocks of central New York. Geol. Soc. America, Bull., vol. 4, pp. 91-118, 1893. The thickness of the Devonian and Silurian rocks of western New York approximately along the Genesee river. Rochester Acad. Sci., Proc., vol. 2, pp. 49-104, plates. 1892.

PLATE 1.



STRATIGRAPHIC SECTIONS OF THE UPPER SILURIAN FORMATIONS OF CENTRAL AND EASTERN NEW YORK.

Vertical scale, 725 feet to 1 inch.
Horizontal spacing, 115 miles to 1 inch.

burner * with the Helderberg formation according to my own interpretation. The sections at Catskill and Rondout are from Davis, with slight modifications, and the New Jersey column is mainly compiled from the publication of I. C. White † and Barrett.

The datum line for these sections is the base of the Hamilton group which is a remarkably continuous and sharply-defined horizon throughout. The transition from limestone to shales is everywhere abrupt, and I believe constant in horizon from Pennsylvania through New York to western Canada.

The only important variation in the Onondaga limestone is the diminution of its thickness for some distance southward from the Helderberg mountains and its great expansion in northern New Jersey. It is everywhere a blue-gray pure limestone, predominantly cherty in its upper portion. In western New York and in Pennsylvania it comprises several more or less distinctly separable members, but in eastern New York subdivisional distinctions are not obvious. In plate 1 the Schoharie grit is not indicated. This is a thin member which appears to be a local phase of the earlier Onondaga deposits in the Schoharie and Helderberg region, although strongly characterized by its distinctive fauna. The shales and slates which have been known as the "Caudi-galli grit" attain their maximum development in New York about Catskill and Kingston, thinning gradually to seventy feet at Schoharie, forty feet near Jordansville, north of Richfield Springs, three feet at Columbia, northwest of Richfield Springs, and it is entirely absent at Litchfield, eight miles farther west. This rock expands greatly in New Jersey.

The Oriskany sandstone is a thin, irregular predominantly arenaceous deposit overlying the Caudi-galli beds and extending westward in disconnected outliers to a considerable distance beyond Cayuga lake. In eastern New York it is often very calcareous, or cherty. In Greene county it is discontinuous over a

* Petroleum and natural gas in New York State. Am. Inst. Mining Engineers, Trans., vol. 16, pp. 906–953, plates. 1889.

† Second Geol. Survey of Penn. Report G6, Pike and Monroe counties, pp. 74–75. 1882. "Notes on the Lower Helderberg rocks of Port Jervis, N. Y." N. Y. Lyceum of Nat. Hist. Annals, vol. 11, pp. 290–299. 1876, and Am. Jour. Sci., 3d series, vol. 13, pp. 385–387. 1877. "The Coralline or Niagara Limestone of the Appalachian system as represented at Nearpass's Cliff, Montague, New Jersey." Am. Jour. Sci., 3d series, vol. 15, pp. 370–372. 1878.

considerable area or represented by occasional lenses of chert. In Ulster county it attains a thickness of thirty feet, but is usually about ten feet thick and is predominantly calcareous. In central New York, also, the thickness and character is variable; at Columbia, in Herkimer county, it is a silicious limestone ten feet thick, but a few miles west it is absent, though reappearing farther to the westward. South of Utica it comes in again as a bed of quartzite three to six feet thick, which thickens to eighteen to twenty feet at Oriskany Falls. "Between Elbridge and Skaneateles, on the old Seneca road, the sandstone shows itself on the road, and of a thickness of about thirty feet."* Thence westward it is represented by lenticular masses of quartzite of greater or less length, and varying from a mere film to six or eight feet in thickness. Hall reports the westernmost outcrop at Morganville, in Genesee county.†

The Helderberg limestones attain their greatest development in eastern New York, and the thickness reported by Davis of about 300 feet in the Catskill region is the maximum. They thin gradually southward in New York, but expand again in New Jersey. In the Helderberg mountains there are 200 feet, and at Schoharie not over 240 feet. Westward from Schoharie

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*Vanuxem; Final Report on the Third District of New York. p. 126. 1842.

†A section of the Lower Helderberg as represented in Schoharie and Albany counties is as follows, from the top downwards:

1. A crystalline gray, heavy-bedded limestone, largely consisting of broken and drifted fragments of fossils and known as the upper Pentamerus beds.

2. A series of highly fossiliferous shaly limestone beds, known as the Shaly limestone of the Lower Helderberg. This part of the formation has furnished much the greater portion of the fossils from the Lower Helderberg series.

3. Heavy-bedded gray subcrystalline limestone containing abundant fossils, which are mainly in a fragmentary condition. This formation is locally known as the lower Pentamerus, or Pentamerus beds of the Lower Helderberg.

4. The Tentaculite limestone, consisting in the upper part of heavy-bedded, dark-blue limestones, becoming below and finally alternating in layers of a quarter to one-half an inch in thickness, with similarly attenuated layers of the upper part of the waterlime.

At Hudson, on the east side of the Hudson river, the Lower Helderberg gives the following: A shaly or irregularly thinly-bedded limestone, quite fossiliferous in character. This limestone is much more developed in the neighborhood of Catskill and Rondout than at Hudson.

1. A heavy-bedded crystalline limestone, usually known as the Scutella limestone and now proposed to be designated as the Becraft limestone, from the locality, Becraft's mountain. This Scutella limestone in some localities of the Helderberg region merges with the upper Pentamerus limestone. They are undoubtedly of corresponding age.

2. Shaly limestone, highly fossiliferous, but not so readily decomposing as in the Helderberg and at Schoharie.

3. The lower Pentamerus beds, less developed than in the Helderberg and Schoharie.

4. Tentaculite limestone, which is usually less heavily bedded and of lighter color than in the Helderberg and Schoharie, the upper beds being sometimes semi-crystalline.—H.

the thickness decreases very gradually. The members constituting the formation in its typical development, beginning at the top, are a pure semi-crystalline, massive, very fossiliferous limestone, a thick series of shaly limestone, and the basal series, thin-bedded dark limestones of the Tentaculite beds. On Catskill creek a higher member of impure shaly limestone comes in above the pure, massive beds, thickens rapidly, and continues southward to and through New Jersey. The Helderberg formation preserves its typical characters with some local variations in thickness, to a few miles west of Cherry Valley. Then the upper limestone beds thin out, and on the road from West Winfield to Litchfield in the southwestern corner of Herkimer county, the Pentamerus beds lie directly under the Onondaga limestone. This, however, as I shall show beyond, is a region of uplift and erosion in pre-Onondaga times, which has removed the Oriskany sandstone and upper members of the Helderberg limestones which come in again westward, and are finely exposed at Oriskany Falls. S. G. Williams* has described and discussed in detail the relations at this locality, and I shall only briefly mention them. Here 120 feet of beds are exposed in and about the quarries, of which fifty feet are quite distinctively of the Tentaculite beds, forty feet of gray beds in greater part of Pentamerus limestone age, but merging into the character of the lower beds, a few feet of beds with mixed Pentamerus and shaly limestone fauna, and, at the top, twenty-five feet of gray subcrystalline rock containing a shaly limestone fauna. Twenty-five miles west of Perryville, Madison county, I found that this condition had continued, the lower members expanding apparently at the expense of the Pentamerus beds, and the upper members giving place to Pentamerus beds. At this locality the Onondaga limestone was seen lying on a few feet of dark gray limestones containing *Pentamerus*, with a thin local intervening layer of Oriskany at one point, which gave place to a great mass of thin-bedded gray limestone below. S. G. Williams† has called atten-

* The westward extension of rocks of the Lower Helderberg age in New York. Am. Jour. Sci., 3d series, vol. 31, pp. 139-145; Abstract Am. Assoc. Adv. Sci., Proc, vol. 34, pp. 235, 236; Am. Nat., vol. 20, p. 373. 1886.

† Ibid., and Note on the Lower Helderberg rocks of Cayuga lake, New York. 6th Report of State Geologist, 1886, pp. 10-12; Abstract Am. Assoc. Adv. Sci., vol. 35, pp. 214, 215. 1887.

tion to the Helderberg fauna in the thin-bedded limestones lying between the Oriskany and waterlime rocks about Cayuga lake, and in this region these members constitute the formation in its western extension, apparently finally giving place to the waterlime strata.

The Salina formation, which is such a prominent member of the series in central and western New York, thins rapidly eastward and is finally represented by an attenuated development of its upper members. This representative is the waterlime series which is more or less continuous through eastern New York, northern New Jersey and Pennsylvania. In the country of the Helderberg mountains it is not always easily recognizable, and when present is often not over a yard in thickness. About Rondout and Rosendale it comprises thick beds of valuable cement rock, and at Howe's Cave there is also a cement bed of workable thickness. Buff shaly members of the Salina come in under the waterlime beds at Sharon Springs, and red shales north of Richfield Springs, and the formation thickens rapidly from here westward.

The Niagara formation in Onondaga and Madison counties thins rapidly to the eastward, and the last exposure, according to Vanuxem, is on Steele's creek, south of Mohawk. It comes in again over a small area extending about Schoharie and Howe's Cave, in which it has a thickness averaging about five feet. I saw no trace of its presence in Albany county, but there are small outliers near the Catskill and about Rondout. To the south of Rondout it is certainly absent for many miles, but it comes in again in New Jersey where Barrett reports a thickness of fifty feet. In its eastward extension the Clinton formation overlaps the Niagara for some miles, finally thinning out in the southwestern corner of Madison county near Salt Springville. It comes in again with the Niagara limestone about Howe's Cave and Schoharie as a pyritiferous green shale, which attains a thickness of about forty feet. A short distance south of Rondout there begins a formation comprising a thin-bedded vitreous quartzite above and red to gray shales below, which extends southward between the Shawangunk grit and Salina formation. South of Rosendale the quartzite member finally gives place to gray sandstones with gray and red shales. The character and relations of this formation lead me to believe that it is Clinton in age, and I have so represented it in the sections and on the maps. Davis * observed it at its northern termination where it overlaps the Hudson river shales, and suggested that it was the northern termination of the Oneida and Shawangunk grit, but the latter comes in beneath it a few miles south and is seen to be entirely separate.

The arenaceous sediments of the Oneida and Medina formations thin out and disappear a short distance east of Voorheesville in the southeastern corner of Herkimer county, and there are no traces of their representatives to the east and south to Ulster county. Between Rondout and Rosendale the Shawangunk grit begins, and this probably is of Oneida and Medina age, either or both. It is a white quartzitic conglomerate, which thickens rapidly and constitutes the upper part of the Shawangunk mountain and its southern continuation. In Sullivan county an upper member of red and buff sandstones appears in its upper part, and increasing greatly in thickness the two members become the Oneida and Medina of New Jersey and Pennsylvania geologists, and in Virginia the Massanutten sandstone of Darton.

The Formations. *Onondaga limestone.* — This is the limestone series which is usually termed "Corniferous" by many writers but by others the upper member of the series is termed "Corniferous" and the lower, "Onondaga." As both members are cherty, the term "Corniferous" implies a contradistinction which does not exist, and it is now proposed by the State Geologist to revive the term "Onondaga" to comprise the entire series. It is a well-known name in western New York where the beds are extensively quarried, and the formation is typically developed in the Onondaga region. As the name "Salina" has been finally adopted for the salt and gypsum group of the upper Silurian there need be no confusion attending the general use of "Onondaga" for the limestone, as proposed.

The subdivisions of the Onondaga limestone gradually lose their physical and faunal characteristics in eastern New York and the formation is in greater part a light blue-gray subcrystalline, tough, massive pure limestone with lenticular masses of

* The Nonconformity at Rondout, N. Y.; Am. Jour. Sci., 3d series, vol. 26, pp. 389-395. 1883

chert in courses and irregularly disseminated. Darker colors occur locally, notably in the upper beds about Peoria (West Berne), which are very dark and coarsely crystalline. The chert is predominant in the upper beds but it is usually present also in the lower beds. In places it is an inconspicuous feature but this is not often the case.

Thin partings of shale occur rarely. About Saugerties the lower portion of the limestone is impure and weathers buff. About Clarksville the lower members are very pure, free from chert and regularly bedded.

Fossils have been found by me very sparingly south of Albany county, but about the Helderbergs, Schoharie and westward the lower members are often very fossiliferous, notably from Thompson's lake to Peoria where the formation comprises many fossil coral reefs, some of large size.

In Greene and Ulster counties particularly, the outcropping edge of the formation is characterized by a fringe of very large disconnected blocks occurring at various intervals. In some cases these blocks lie several hundred yards from the main outcrop of the formation and appear to be glacial erratics. No doubt some are, but I have found that many are undoubtedly in place, having resisted the erosion which has removed the surrounding mass of limestone. Notable examples of these blocks may be seen in the Kaaterskill creek region, as recorded by Davis, on the road from Katshaan southward, on the road north from Aquetuck creek, northeast of Coeymans Hollow, and north of Cottekill.

Schoharie grit.— This is a local deposit which is characterized in the vicinity of Schoharie, and extends through Schoharie and Albany counties, and along the eastern outcrop to Ulster county. It is a very arenaceous limestone, which weathers at the surface to a dark buff or brown, porous, massive, rather tough sandrock. It merges into the Onondaga limestone above, but is more sharply separated from the underlying formation. It is characterized by an extensive fauna, of which the members appear in great profusion as casts in the weathered sandrock. East from Schoharie the formation was not again seen until reaching the eastern face of the Helderberg mountains, and near Clarksville, where it is well exposed. It appears to be absent for some miles

PLATE 2.

ARCH IN ESOPUS SLATE ON THE CATSKILL AT LEEDS, N. Y. LOOKING SOUTH.

in the region southeast of Altamont, for I saw several exposures of its horizon in which it was not characterized. The southernmost occurrence I have noted is along the road on the slope three-quarters of a mile south of Callanan's Corners, where its thickness is about six feet. In Greene and Ulster counties some of the impure basal beds of the Onondaga limestone resemble Schoharie grit, but they are less arenaceous and appear to lack the characteristic Schoharie grit fauna. Southwest of Coxsackie there are several exposures in which typical Corniferous limestones were seen lying directly on the Esopus slate, and here the Schoharie is undoubtedly absent.

Cauda-galli grit=Esopus slate.— In order to have a locality designation for the Cauda-galli grit, the State Geologist has suggested the name Esopus slate, from the Esopus settlement, of which the portion now known as Kingston is largely on this formation; and the Esopus creek, along which for some miles above Saugerties the slates are particularly well exposed. The formation is, in greater part, a fine-grained arenaceous deposit of dark-gray color, and with more or less completely developed slaty cleavage. About Schoharie and westward to its termination it is a moderately hard, sandy shale varying in color from dark gray or buff to light olive, but east and south with increasing thickness the color becomes darker, the texture of the rock is harder and slaty cleavage is general. In the Helderberg mountains and westward the shales constitute a slope between shelves of Onondaga limestone above, and Oriskany sandstone below, as shown in figures 4 and 5, but from the southern part of Albany county, southward, it constitutes high rough ridges.

Notwithstanding the slaty cleavage, bedding planes are occasionally distinct and they usually exhibit impressions of the *Spirophyton cauda-galli* which are seen so often on the shaly beds westward. This is particularly the case where the beds are slightly quartzitic, a feature not unusual in the upper portion of the formation notably about Clarksville and near Leeds. The formation has a thickness of 110 feet at Clarksville and is very finely exposed in the vicinity of the village and down the creek, from the quartzitic members lying just below the Schoharie grit at the old mill, to the members with strong slaty cleavage in columnar walls along the gorge half a mile below.

South of South Bethlehem the area of the Esopus slates widens in the folded region and they outcrop in a succession of steep ridges of moderate height, nearly barren, and presenting a characteristically dismal aspect. Some of the most conspicuous of these ridges, three miles south of South Bethlehem, have very precipitous, rocky sides, 100 to 150 feet in height, and remarkably abrupt terminations. The rock of this region and southward is a very hard, arenaceous shale, with well-defined, vertical cleavage throughout, and bedding planes almost entirely obliterated. The colors are dark gray, slate, blue-black and black. Southwest of Saugerties, and at some other points, the rock is very black and fine grained, somewhat resembling cannel coal at first glance. The principal exposures are along the west side of Esopus creek, from a short distance above Saugerties to Glenerie, where the dark slates outcrop in very high, bare banks.

Oriskany sandstone.— The remarkable persistence of this very thin, arenaceous deposit and its characteristic fauna renders it a particularly interesting formation. It varies in character from an arenaceous limestone to a quartzite, and a conglomerate, and its thickness is seldom over three feet. It is often discontinuous for greater or less intervals but is seldom absent for any long distance. At Schoharie it is a thin layer of very silicious limestone or calcareous sandstone not unlike Schoharie grit in composition and appearance, similarly weathering to a porous, buff sandrock filled with casts of fossils. In the slope south of Gallupville it is a three-foot bed of black quartzite but on the Fox kill above Gallupville it is more calcareous. About Knox and on the road eastward toward Altamont it is a gray, or brownish gray, quartzite two or three feet thick, bared over a considerable area in a gently south dipping floor. Due south of Altamont an east and west road passes along a floor of this character for over a mile, the underlying limestone showing through at a few points. Along the eastern front of the Helderberg mountains and to Callanan's Corners, the formation is a bed of gray-brown quartzite averaging two and a half feet in thickness and apparently continuous. Thence southward the continuity of the formation, in its extension eastward over the folded region, is frequently interrupted and the quartzite is rarely seen. Its place is taken by thin lenses of black chert of small area in greater part associated with gravel streaks. Near the Catskill, Davis describes a six-inch layer lying on the Helderberg formation, consisting of limestone pebbles up to an inch in diameter, intermixed with coarse quartz grains, which he considers Oriskany. West of Saugerties, on the road to Quarryville, the Oriskany is represented by a six to eight foot bed of dark quartzite, with calcareous layers exhibiting fossils, and this bed is also seen with somewhat diminished thickness along Esopus creek toward Glenerie. From here southward the formation appears to be continuous and its thickness increases. Davis reports about Kingston twenty to thirty feet of Oriskany, consisting of an unfossiliferous lower member, in places absent, of white quartz sand in part a quartzite, but "sometimes loosely built of subangular white pebbles up to an inch in diameter," and an upper member of fossiliferous white grit. I could not find so great a thickness, but my observations in this vicinity were not extensive.

Along the Wallkill Valley railroad the Oriskany is exposed for several miles north from Whiteport, and consists of a calcareous sandrock merging into dark quartzite, the former exhibiting abundant fossils in its weathered portions.

Just south of Cottekill the formation is a dark-blue, fine-grained silicious limestone four or five feet in thickness and moderately fossiliferous. Its character is similar along the eastern slope of Stone Ridge, where I observed it at several points. The last exposure I saw southward was a half mile north of Wawarsing, where it was a dark-gray, silicious limestone ten to fifteen feet in thickness.

The Oriskany formation has recently been described by Beecher and Clarke on Becraft mountain, south of the city of Hudson, where it consists of a few feet of arenaceous limestone, presenting the usual physical features and carrying an interesting fauna.*

Helderberg limestones.—The members comprised under this name are upper Shaly beds, the Scutella or upper Pentamerus beds, the lower Shaly beds, the Pentamerus beds and the Tentac-

*Notice of a new lower Oriskany fauna in Columbia county, New York. Am. Jour. Sci., 3d series, vol. 44, pp. 410–18. 1892.

ulite beds. These members preserve their distinctive characters throughout the region to which the report relates, although there are occasional slight local variations.

The so-called Scutella beds are the uppermost member southward to near Catskill. They are a light colored, coarsely semi-crystalline, massively bedded, highly fossiliferous limestone, blotched with calcite replacements of fossils, of which the most conspicuous is the so-called Scutella. These are the cups or pelvis of a crinoid, having a diameter in greater part from one to two inches, and the white calcite of which they consist contrasts strongly with the light bluish gray of the containing limestone. In the Schoharie region, where these cups characterize the lower beds of the member, the overlying layers have been called the upper Pentamerus beds from the *P. pseudogaleatus* which they contain, and this name has also been employed to some extent to comprise all the beds. In the eastern extension of the formation the distinction is lost. About Catskill, Davis designates the lower layers the "Encrinal" and the upper layers the "upper Pentamerus" limestone. Owing to the inappropriateness of the name "Scutella" and the varying significance of the other terms which have been employed, the geographic name of Becraft limestone has been suggested to me by Dr. Hall. The name is from Becraft's mountain in Columbia county where the rock is typically developed. The Becraft limestone has a thickness of ten to fifteen feet about Schoharie and the amount does not vary greatly eastward to the Helderberg mountains and by Clarksville, Aquetuck and Coxsackie. Thence it increases rapidly and Davis reports a thickness of 120 feet below Leeds, the upper ten feet consisting of impure sandy and shaly layers. There are, as Davis suggests, many local slips in this section and my estimate of the thickness of the purer limestone would be about sixty feet. The sandy and shaly beds are the beginning either of a separate later deposit, or an expansion of the Becraft deposit, which rapidly increases in thickness southward and is the "upper Shaly limestone" differentiated by Davis about Rondout. In the vicinity of Saugerties the Becraft limestone is of the usual light-gray, massive, coarse-grained fossiliferous character and has a thickness of twenty-two feet. It gives place above to the upper Shaly beds which have a thickness of about thirty-five feet and consist of very impure dark-gray limestones with more or less well-defined slaty cleavage and a moderate abundance of fossils. In the Rondout region the Becraft limestone is forty feet thick and the upper Shaly beds 100 to 150 feet, according to Davis, but these amounts appear to me to be too great. In the ridge just east of Whiteport there are thirty feet of Becraft limestone and fifty feet of the upper Shaly beds; and in a fine exposure on the railroad just south of Whiteport station, about ten feet less of each. About Rosendale and southward I saw no exposures.

Underlying the Becraft limestone beds throughout, there are the lower Shaly beds consisting of thin bedded, very impure, highly fossilferous limestones containing some shale and varying in color from gray and drab to dull buff. At some localities, for instance, westward on the Fox kill above Gallupville, it is in greater part a massive, relatively pure limestone. In Greene and Ulster counties it has the character of the upper Shaly beds with a more or less slaty cleavage and outcropping in ragged edges, in some cases closely resembling the lighter-colored outcrops of Esopus shale. Its thickness from Schoharie eastward is about eighty feet, and there and elsewhere in the great Helderberg escarpment it constitutes a steep slope between the Scutella and Oriskany shelf above and the Pentamerus escarpment below. Its thickness apparently decreases somewhat in the Kingston–Rosendale region, but it retains its characteristics. I saw no outcrops south from High Falls and do not know where it begins to thicken again. Davis reports fifty to sixty feet on Becraft's mountain.

The Pentamerus beds, known also as the "lower Pentamerus limestone" are the most conspicuous member of the Helderberg formation, giving rise to the conspicuous escarpment characterizing the eastern outcrop line of this formation throughout the greater part of its course from central New York to beyond Rosendale. The beds consist of a hard, very massively bedded, vertically jointed limestone, and these characters, together with undermining caused by the rapid erosion of the thin bedded and softer underlying beds, give rise to the escarpments. Some features of the beds are shown in the following figure.

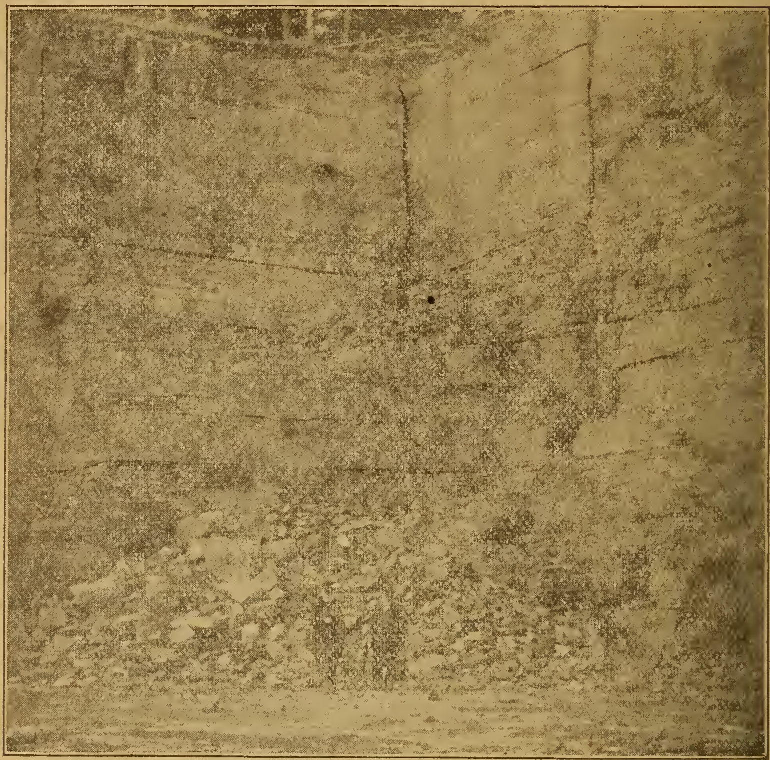

FIG. 1.— Pentamerus and Tentaculite beds in a quarry at Howe's Cave, Schoharie county Looking northwest. From a photograph.

The color of the rock is a bluish gray, generally weathering to a somewhat lighter tint. Besides the thick regular bedding there is also an irregular sub-bedding into flat interlocking lenses and corrugations, of which the outlines are brought out by weathering. Occasional slate partings occur, and also nodules of chert, especially to the east and south. The character of this member is very uniform throughout, and its thickness does not vary greatly. At Schoharie its amount is between sixty and seventy feet, in the Helderbergs the same, a trifle more about Catskill — eighty feet according to Davis — fifty feet at Saugerties, thirty to forty feet about Rondout, seventy to one hundred feet about Rosendale, the maximum being in the high ridge just northwest of the village. Its thickness decreases southward toward Ellenville. The Pentamerus beds are quite sharply demarked from adjoining beds, a few inches of passage beds intervening.

The finest exposures of the Pentamerus ledges are in the great escarpment of the Helderberg mountains, near the Indian Ladder where they rise in great cliffs surmounting steep slopes to an altitude of 700 feet above the plain lying to the north and east. The cliffs on the eastern slope of the West mountain, opposite Schoharie, are also very imposing, as may be seen in some measure in the illustrated figure 4.

The Tentaculite beds are thin-bedded dark-blue limestones, lying below the Pentamerus beds, and usually constituting the base of the Pentamerus escarpment or lying beneath its talus. The beds vary in thickness from an inch to a foot in greater part, but two or three inches is the general average. Some intercalated shaly layers are sometimes noticeable. In the upper members there is a thin sub-bedding, indicated by a ribboning of alternating lighter and darker tints, constituting the "Ribbon limestone" of some writers. Just below this ribboned series there is usually a thin bed of Stromatopora, which characterizes this horizon. The Tentaculite beds have a thickness of forty feet at Howe's Cave and Schoharie, somewhat less in the Helderberg mountains, and from thirty to forty feet through the Catskill and Kingston regions. In the Rosendale region the amount is less. Some features of the Tentaculite beds are illustrated in figures 3 and 4.

There are several outliers of the Helderberg limestone which are of great interest as indications of the original extent of the formation. One of the most noteworthy outliers is on Becraft's mountain a short distance southeast of Hudson, which has been described in detail by Davis.* It is a small, shallow, oblong synclinal area covering about two square miles and exhibiting Tentaculite, Pentamerus, lower Shaly and Becraft beds, together with Oriskany, Esopus shale and a very small outlier of Onondaga limestone before referred to. The Tentaculite beds are described as fine, blue, even, thin beds, weathering light colored and smooth and having a thickness of twenty to thirty feet.

* Becraft's mountain; Am. Jour. Sci., 3d series, vol. 26, pp. 381–389. 1883.

The Pentamerus beds, "heavy knotted, grayish-blue beds with irregular nodules of chert" and a thickness of forty to fifty feet, Shaly beds, "deep blue, weathering brown and shaly," thickness fifty to sixty feet, Scutella beds, "hard-gray crystalline limestone, largely made of fragments of shells in somewhat even layers," thickness forty to fifty feet.

Two miles northeast of Becraft's mountain there is another outlier constituting a knob known as Mount Ida or Mount Bob. It has recently been described in detail by T. W. Harris,* who finds that it is a synclinal area containing Tentaculite, Pentamerus and Shaly limestone beds presenting the usual characteristics.

In Orange county, N. Y., in the great synclinal of Skunemunk mountain there are several outlying areas of Helderberg limestones of which the most notable is at Cornwall Station. The relations at this locality were described by N. H. Darton in 1886.† Although miles from the edge of the main Helderberg belt to the westward, the Tentaculite, Pentamerus and Shaly limestone beds are well characterized at this point, the latter containing nodules of hematites and a great profusion of beautiful casts of fossils.

Salina waterlime.— The attenuated eastern extension of the great Salina formation is of variable character and thickness and may not be continuous throughout. Locally it consists of heavy beds of cement rock but generally it is composed of thin beds of more or less impure cement intercalated with thin-bedded limestones of various character. The cement beds attain their greatest development about Rosendale and Rondout where they are extensively worked. The cement rock is a blue black, very fine grained, massively bedded deposit consisting of calcareous, magnesian and argillaceous materials, and is of somewhat variable composition. The rock produces a cement of good quality only when these components bear certain relative proportions to each other. A characteristic feature of the rock is the light buff hue to which its surface weathers. At Rosendale there is a twenty-one foot bed of cement at the base of the formation, then from twelve to fifteen feet of mixed impure cement and

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*Am. Jour. Sci., 3d series, vol. 43, pp. 236–238. 1892.

† On an area of Upper Silurian rocks near Cornwall Station, Orange county, N. Y., Am. Jour. Sci., 3d series vol. 31, pp. 209–216.

limestone beds, then another cement bed eleven feet in thickness. Above these are the Tentaculite and Pentamerus beds. Throughout the Rosendale region the local cement bed lies conformably [?] on a floor of quartzite of Clinton age and it is unusually sandy for the first few inches above. In the following figure the relations of these beds are shown.

These cement beds with some variations in thickness, and many in character, extend over a wide area from north of Whiteport through Rosendale to beyond High Falls, outcropping in a belt about eight miles in length by two and a half in width. At High Falls there is an upper bed of cement fifteen feet thick and a lower bed five feet thick separated by three feet of impure limestone. At Whiteport the upper cement is twelve feet thick, the lower from fifteen to twenty and the intervening limestone ten feet in thickness. How far they may extend under the overlying rocks to the westward is not known and their southern termination has not been explored. To the northeast the cement thins out rapidly and gives place to impure cements and limestones, but it thickens again rapidly in the Rondout region. At Rondout there are two cement beds, the lower twenty-two feet thick and the upper five feet thick with three feet of mixed limestone and cement intervening. Northward the lower cement bed thins gradually and the intervening limestone and the upper cement thicken. North of East Kingston the cement beds become interstratified with limestone and give place to thin interbeddings of limestone and waterlime beds.

Near Saugerties, Catskill, Coxsackie and South Bethlehem the formation is exposed at a number of points but no beds of cement are known to exist in it. Its thickness in this region varies from thirty-five to fifteen feet, and decreases northward. In the Helderberg mountains the entire thickness of the calcareous strata below the Pentamerus beds is only thirty feet, which consist in greater part of Tentaculite beds, with a few feet of Salina beds at the base. The thickness is much greater south of Quaker Street where cement beds are reported. About Schoharie the thickness is thirty feet but no important cement beds have been worked for the market. At Howe's Cave the thickness is forty feet and at the base there is a six-foot bed of cement which is worked for the market.

A noticable feature of the Salina formation in eastern New York is a reticulation of sun cracks on what apparently is its upper surface, a feature which I have noticed in every exposure.

Niagara limestone. — In the Schoharie region the attenuated eastern representative of the formation is exposed at many points for a considerable distance. Its thickness averages five feet and it consists of a massive bed of dark-colored limestone, weathering to light-gray, and containing corals. At Howe's Cave it is especially well exposed just below the cement quarries of which it constitutes the floor. Some of its relations at this locality are shown in plates 3 and 4.

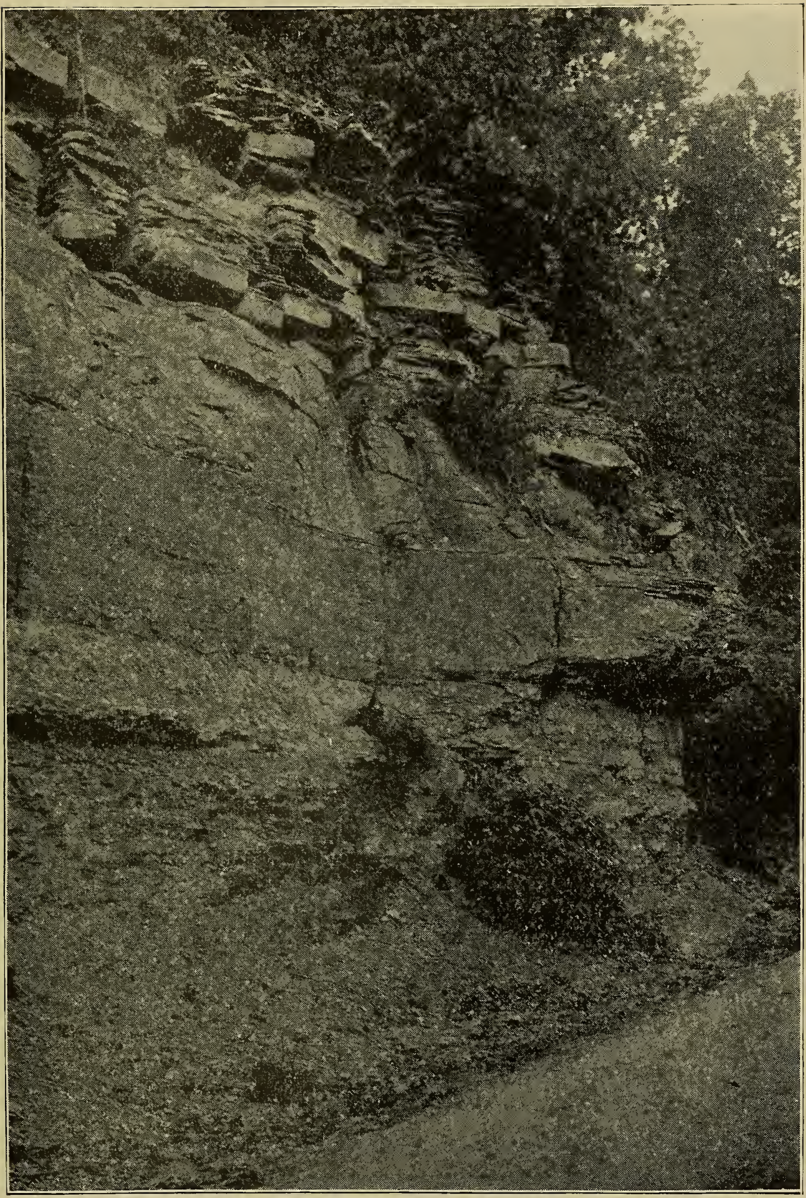
The location of the terminations of the stratum about Schoharie is not known, for owing to lack of outcrops I could not find them.*

The formation is absent in the Helderberg mountain region and by Coxsackie, but it comes in again near Catskill creek and extends to West Camp where I found it to have a thickness of about three feet. It appears to be absent about Saugerties but I did not satisfy myself on this point. It is exposed in the Rondout quarries where Lindley, Dale and Davis refer to its presence. Its thickness about Rondout is six feet, and its coralline character is conspicuous. It is absent in the Whiteport–Rosendale region, and so far as I could determine, also at High Falls. Its presence in the Ellenville region was not determined, for the drift cover is heavy and the few outcrops were all of higher and lower rocks.

Clinton formation.— The pyritiferous shales about Schoharie which belong to the Clinton age are seen only at rare intervals. There is one obscure exposure on the slope of the hill just northeast of the village, another on the creek a few hundred yards above the bridge and several along the base of West mountain to the northward. At Howe's Cave there is a fine exposure in an excavation just below the cement quarries, which is shown in plate 4, and the upper beds are shown in plate 3. The thickness at this point is about forty feet, and the formation a mass of

*The Niagara ("Coralline") limestone crops out along the road going obliquely up the hill at the northeasterly end of the village of Schoharie, and continues for more than a mile along the northerly escarpment of the terrace. A building (a small church) has been erected upon this outcrop from stone quarried on the north side of the road just referred to.—H.

PLATE 3.



Niagara Limestone and Associated beds on the Cobleskill near Howe's Cave, Schoharie County, N. Y. Looking Northwest. The Niagara Limestone is the Heavy Stratum in the Middle of the Section, Six or Seven Feet of Clinton Shales Lying Below, and the Massive Cement Bed and the Thin-bedded Tentaculite Layers Above.

soft, pyritiferous shale, crumbling rapidly on exposure. It is included between the Niagara limestone above and the Hudson river shales exposed a short distance below. The exposure was found to terminate a short distance northwest of Howe's Cave, and it does not appear to extend far east from Schoharie.*

The beds holding approximately the same position of this, beginning at Eddyville near Rondout and extending southward, are quite different from those of the Schoharie exposure. There comes in front an upper member of white or gray thin-bedded quartzite, which is followed in a few miles by an underlying series of hard shales varying in color from red to brown. These continue for several miles with an average thickness of about twenty feet each, the quartzite constituting the floor of the cement quarries in the Rosendale–Whiteport region. One of the finest typical exposures of these beds is in the cement quarries two miles northeast of Rosendale. Here the quartzite is twenty-two feet thick and consists of regular beds three to twelve inches in thickness, in greater part welded together, of light gray color with buff-brown streaks, many of the beds having a characteristic cross-bedding within themselves, brought out by slight differences in tint. The overlying cement is perfectly conformable and in greater part welded to the quartzite, but is strongly contrasted by the great dissimilarity of its materials. The shales lying below the quartzite are in greater part dark dull red in color, moderately fine grained, massively bedded as a whole but breaking into shale on exposure, and have a thickness of twenty-five feet; one or two beds are of a dirty buff tint in part, and at the top there are two inches of gray shale which abruptly give place to the quartzite. About four inches below the top there is a two-inch layer of breccia of small angular masses of dark gray-blue cement-like materials in a gray sand matrix. The lower portion of the shales merges into two or three feet of dull gray-green grits with blotches of pyrite, and some small quartz pebbles which lie on the Hudson river shales and may represent the beginning of the Shawangunk grit.

The formation is again well exposed in the railroad cuts (Red Rock cut) between Binnewater and Whiteport, a mile due west

* The exposure terminates by dipping beneath the surface along the road to the southwest from Howe's Cave.—H.

from the exposure above described. The quartzite member is here about twenty feet thick and well characterized. Flesh, buff and pink tints prevail, alternating in thick beds or ribbonings, and also in cross-bedding within the beds. The shaly member has a thickness of about twenty feet, and is quite a bright red shale, lying on the Shawangunk grit. The formation comes up again a short distance north, where the shales are seen to be darker in color and considerably thicker.

In the immediate vicinity of Rosendale the quartzite is often exposed in and near the cement quarries, of which it is the floor, and it has the same characteristics as above described. The red shale is less frequently exposed, for Rondout creek runs along its outcrop line for some distance, and it is much covered by talus elsewhere.

In the banks just below the High falls on the Rondout there is a fine exposure of the rock of this horizon. The quartzitic member is seen to have increased in thickness somewhat, and has given place to gray sandstone containing intercalations of red, gray and buff shales. The shale member below has a thickness of about twenty-five feet, and consists of gray shales above and red shales below, with intercalated buff and greenish shales and sandstones.

In the synclinal area, two miles southeast of High falls, bright red shales are seen in the lower portion of the formation. The overlying beds were not observed. These red shales are again exposed at the end of the anticlinal just southeast of Port Jackson. Along the base of the western slope of the Shawangunk mountain to Ellenville and beyond, I have seen but few outcrops. Those which I have observed at this horizon were of red and brown shales, lying low on the slope or at the creek bed.

Shawangunk grit.— This formation is a great sheet of silicified quartz conglomerate lying on the Hudson river shales and giving rise to the Shawangunk mountain. The first appearance of the formation northward is between Binnewater and Whiteport, and in the cement quarries on the eastern side of the ridge, as before noted. In the anticlinal, north of Binnewater, the thickness rapidly increases to sixty feet, but to the eastward it thickens less rapidly and it is discontinuous at several points. Just south of Rosendale it thickens rapidly from east to west to about forty-

PLATE 4.

CLINTON SHALES AND OVERLYING NIAGARA LIMESTONE, HOWE'S CAVE, SCHOHARIE COUNTY. LOOKING WEST.

five feet, and to a hundred feet in the ridges which rise to the southwest. About Lake Mohonk fully 160 feet are exposed and at the falls of the Peterkill there are 110 feet, but these are localities at which the upper part of the formation has been more or less deeply eroded. The thickness of the formation in the wider part of the mountain is about 200 feet, for in Sam's point and Millbrook mountain the precipices expose fully this amount. Along the western slope, near Ellenville, 200 feet seems to be a fair estimate and the entire thickness is exposed, but I made no exact measurements.

In greater part the rock consists of white quartz pebbles of small or moderate size in a matrix of sand and silicious cement. Locally there are beds of coarse quartzite sandstone, but the conglomerate is the prevailing rock. The color is white with local exceptions of gray, blue-gray or buff, the latter due mainly to staining from pyrites which is frequently disseminated in the rocks. The bedding is predominantly massive, averaging three to four feet, but thinner bedding is sometimes seen particularly in the finer grained materials. The most conspicuous exposure of thinner bedding is at Peterkill Falls.

Hudson river formation — The shales and sandstones of this formation constitute the general basement of the region, and, although I saw much of them, I gave no special attention to their details. They consist of dark gray, brown and black slates and shales, with alternating beds of very fine grained gray, brown to black sandstones in the upper members northward Their thickness is great, but I have made no estimate of its amount. Near Altamont there are nearly 600 feet in the slope to the southward, and the gas well bored in 1886 penetrated 2,880 feet to the Trenton limestone,* giving a total of 3,480 feet as the thickness at that locality.

The Overlaps and their History.

The absence of a portion of the members of the upper Silurian column in part of eastern New York has been discussed at greater or less length by many writers. Davis, in his papers on the Catskill, Becraft's mountain and Rondout regions, has reviewed these discussions and added much new light for these regions. My

* See Ashburner, loc cit., pp. 46–47.

observations have extended this knowledge over the entire belt in New York, although I have not studied the details of all the localities with such care as I desired. I have also examined some features of several overlaps at higher horizons westward.

The general relations are shown in plate 1 and the following figure. The contacts along the overlaps unfortunately are relatively seldom exposed, for they are unusually obscured by talus from cliffs of overlying limestones, and road cuts afford the principal exposures. The aggregate number of contacts which I observed was considerable, and I found many outcrops in which the vicinity of the contacts was exposed.

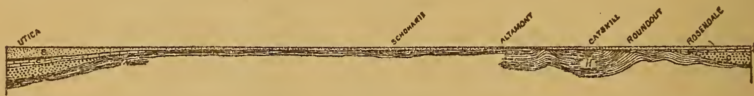


Fig. 2 — Diagram illustrating the stratigraphic relations of the upper Silurian members below the base of the Helderberg formation from Utica to Ellenville. Datum plane is at base of Helderberg formation. S., Salina formation; C., Clinton formation; O., Oneida-Medina; H., Hudson river formation. Vertical scale greatly exaggerated. Dip is apparently only in Rondout to Rosendale region.

Coming eastward from Utica the Niagara limestone runs out first, then the Oneida-Medina beds, then the Clinton, and finally the Salina shales just east of Sharon Springs. I did not study the contacts in this belt but it was very apparent that the formations do not merge into each other or the Hudson river formation below. The Niagara and Clinton outcrops extending from Howe's Cave to Schoharie present no special evidence of unconformity except abrupt breaks in stratigraphic continuity by which they are separated from each other and from the adjoining formations. In the Helderberg mountains at Indian Ladder, the contact was observed and there is perfect conformity in bedding, but the basal limestone bed although quite impure was sharply demarked by its entire dissimilarity from the underlying slate. Just southwest of New Salem the immediate vicinity of the contact was found at a spring at 660 feet A. T. and perfect conformity in dip was observed. South of Feurabush the dips of slate and limestone are coincident so far as I could find. In the flexed region adjoining the Hudson river southward from here there are found areas of conformable bedding merging at intervals into areas of strong structural unconformity.

On Onisketthau creek northeast of South Bethlehem the contact is covered with drift, but the Hudson river slates in the immediate vicinity are vertical and the limestones just west have a general westward dip with a series of gentle undulations. On Sprayt creek, farther within the flexed region, the relations are as is shown in figure 2. In the synclinal ridge eastward there is essential conformity in bedding between the limestones and slates. To the west the eastern dip steepens and continues in the slates, but the limestones lie in a succession of gentle flexures. Along the creek the slates are continuously exposed, dipping steeply eastward and the nearly flat limestones cap the crest of the southern banks. The fault is a local feature dying out a short distance southward and the relations cannot be due to a general overthrust. The limestone here was apparently deposited on a truncated arch of the slates and at the synclinal ridge eastward on a plane.

On the slope just west of Coeymans Junction and at some other points in the vicinity, the Helderberg and Salina beds dip W. 20° and the Hudson river shales and sandstones dip E. 60°. Contacts were not observed but the rocks are seen within a few feet of each other. Two miles southwest of New Baltimore the relations are similar; on Aquetuck creek the contact is obscured, but the unconformity prevails in its vicinity.

On the road two miles southwest of West Coxsackie the limestones and slates are seen near together, dipping 70° east in an overturn; possibly the dip may be slightly steeper in the slates. Davis found essential conformity to prevail in the Catskill region and I found it to continue to West Camp where the Niagara outlier is well exposed. In the Rondout region, as described by Davis, the unconformity is very marked, the Niagara limestone and overlying members dipping steeply westward, and the Hudson river formations steeply eastward. Davis* observed the details of contact here in one of the quarries and found that the limestones filled irregularities in the eroded surface of the slates, precluding the possibility of a fault.

The degree of unconformity decreases southward, and near Rosendale and in the Shawangunk mountain the Shawangunk grit lies on an eroded surface of Hudson river shales, with a

* The Nonconformity at Rondout; Am. Jour. Sci., 3d series, vol. 26, pp. 392–393.

general but moderate difference in the amount of dip. In Orange county the divergence in dip is as great as at Rondout, as is exhibited in the well-known cut west of Otisville. I have not seen this cut recently, and I never satisfied myself as to whether the relations there were due to a fault or entirely to unconformity.

The general history of the overlaps above described is quite obvious, but the precise sequence of events and their local features are not elucidated. The principal factor has been a series of uplifts or deformations, attended with some deposition, in the eastern and east-central New York region during upper Silurian times. Westward the deformation was monoclinal, tilting eastward; in the Hudson valley region there was a flexing preceding the Oneida deposition. The uplift was attended by more or less planing throughout, but apparently both planing and deposition were moderate in amount. It is the irregularity in sequence of overlaps eastward from Utica and in the region south of Rondout that indicated a succession of uplifts. I believe that the overlapping formations extend continuously from the Utica region to the Shawangunk mountains' and New Jersey off to the southwest and south along shore lines trending southeast and south. I interpret the overlaps eastward from Utica as follows: During the Oneida-Medina deposition in central New York there was a shore eastward of Hudson river sediments uplifted by a preceding deformation. This shore was overlapped more or less widely by Medina deposits, which were in turn overlapped by the Clinton deposits. Whether there was uplift and erosion of the Medina deposits eastward preceding Clinton deposition is not known, nor is it known whether the Clinton overlap represents the latest deposits of the Clinton or the attenuated representatives of all the Clinton. The outlier of Clinton at Schoharie may be due to a local bay from the south or isolated by erosion. The limits of Niagara deposition are not apparent, and whether the thinning out in the several areas is due to non-deposition or erosion is not determined. Preceding the deposition of the earlier Salina formations in the Utica region there was uplift eastward, and emerged areas of Niagara, Clinton and Hudson river formation were subjected to a greater or less amount of erosion. The earlier Salina deposits overlapped the Niagara a short distance east of

Utica; and everywhere later deposits, with gradually increasing submergence, overlapped the Clinton, and finally the water-lime beds were deposited over the entire belt eastward, on the Hudson river formation mainly, on the Niagara about Schoharie, Catskill and Rondout, and on the Clinton south of Rondout. This region had been emerged during all early Salina times, and probably also in greater part except locally during Niagara, Clinton, Medina and Oneida times. Of course, it is possible that some or all of the earlier Salina deposits also overlapped more widely and were removed by inter-Salina uplift and erosion, but of this there is no evidence.

In the region adjoining the Hudson the prominent feature is the extended flexing which is shown by the relations in the Rosendale region to have taken place at a time preceding Shawangunk (Oneida-Medina) deposition. There is good evidence also in this region that there was no deformation between Shawangunk and Clinton deposition, the later being attended by increased submergence, which gave rise to the overlap just south of Rondout, but of which the original northern limit is not apparent. The extent of the following (Niagara) deposition is not determined, but its deposits were laid on the eroded flexed Hudson river slates. Then followed Salina deposition at the termination of an interval of planing of unknown amount represented by the lower Salina deposition in western New York. Whether the Niagara formation was originally deposited over the Clinton from Rondout southward and removed by the early Salina erosion is not known. If it was not, then of course the surface of the Clinton in this region was subjected to more or less erosion during Niagara time. The surface of the Hudson river formation in eastern New York was subjected by more or less continuous erosion in eastern New York from the earliest upper Silurian times to the beginning of the deposition of the waterlime members of the Salina and the amount planed off is probably considerable. That we have discovered no channels in its surface westward is rather remarkable, and the apparent perfect conformity of bedding with overlying formations in the monoclinal region is quite remarkable when we consider the various uplifts and erosive periods to which it has been subjected.

There is a small overlap feature in the southwestern corner of Herkimer county which is of interest. Here I found, as I have mentioned above, that the Onondaga limestone lies directly on the Pentamerus limestone, the Oriskany and upper members of the Helderberg formations having been removed, apparently by uplift and erosion, in time just preceding Onondaga deposition. The relations are shown in the following figure:

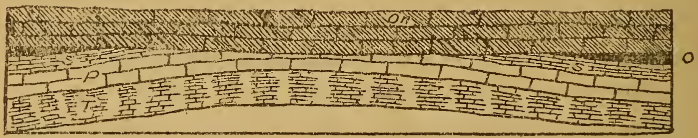


Fig. 3.— Section of overlap in southwestern Herkimer county. On., Onondaga limestone; O., Oriskany; S., Shaly and Becraft limestone; P., Pentamerus beds; T., Tentaculite limestone.

The thinning out of the Esopus shales may be correlated with this uplift either to erosion by it or their shore cutting off their deposition. Possibly, also, the overlap of Onondaga limestone on Oriskany and Helderberg limestone westward may be due to another area of this uplift.

Structure.

General features. — In western and central New York the Palæozoic rocks lie in a great monocline, dipping gently to the southward and traversed by an obscure series of low undulations* having a north and south trend. This structure is not usually perceptible to the eye and the rocks appear to lie flat. An occasional local flexure or slip is exposed but they appear only to involve beds near the surface. Approaching the Hudson river a disturbed region is entered and the undulating monocline rapidly gives place to sharp folds, with some faults, which continue far eastward. This region of folds and faults is the northern continuation of the Appalachian system which extends through New Jersey, New York and eastern New England far into Canada. The greater part of this area of disturbance is in

*Some of these undulations are described by H. S. Williams, Am. Assoc. Adv. Sci., Proc., vol. 31. 1882.

the Hudson river and older formations, but the eastern edge of the Helderberg formations extends eastward on to it for some distance from Albany county southward, in a belt from one to four miles in width, in which are presented the typical features of Appalachian structure but on a somewhat reduced scale. Davis* has described the structure about Catskill and Rondout, and Mather refers in his reports, to various features of the region. Mather, however, misinterpreted the structure in most cases, notably in mistaking Esopus shales for Hudson river shales and the sections on plates 7 and 8 in his final report are in greater part erroneous.

The Monoclinal region.—The structure in the monoclinal region from Schoharie to the Helderberg mountains is very simple, and is shown in figures 4 and 5.

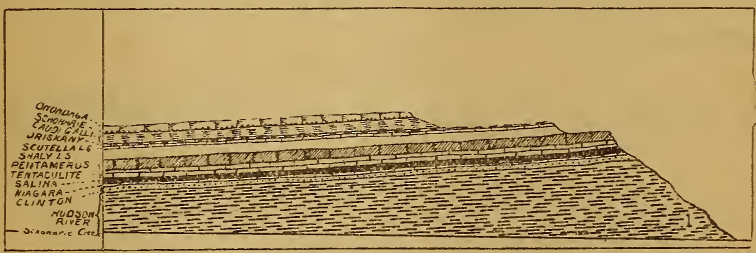


FIG. 4.—Diagram of West mountain, Schoharie.

West mountain beautifully illustrates the sequence and topographic products of the formations in its great escarpment and terraces and has long been known as a typical exposure of the Helderberg rocks.

The rate of dip in this region was estimated from aneroid observations, and the sections shown in figures 11 and 12 were constructed by this means. About Schoharie on section 1, figures 9 and 10, the rate is 100 feet per mile, on section 2, figure 11, 115 feet, and on section 3, 150 feet. These, it should be understood, are not precise determinations, for although the aneroid readings

*The little mountains east of the Catskills; the folded Helderberg limestones east of the Catskills, and the nonconformity at Rondout *ut. cit.*

on which they were based were satisfactory, there is always a considerable range for error in aneroid estimates.

Fig. 5.—Section from near Gallupville across the Helderberg escarpment. H., Hamilton; On., Onondaga limestone; CG, Esopus shale; O., Oriskany; S., Becraft limestone; P., Pentamerus limestone; T., Tentaculite limestone and Salina waterlime; HR., Hudson River formation. Scale, vertical, 3,400 feet to one inch; horizontal, one and three-quarter miles to one inch. Looking west.

Thence southward the Helderberg and associated formations are flexed in true Appalachian type, in a succession of parallel flexures extending north and south for long distances. The inclinations of the strata are in larger part steep and the axes of folds are generally overturned to the west. The flexures give rise to a series of ridges predominantly synclinal but not infrequently anticlinal.

Respectfully yours,

N. H. DARTON.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF ALBANY COUNTY.

JAMES HALL, State Geologist. | N. H. DARTON, Assistant.

1892-1893.

PLATE 1.

THE HELDERBERG ESCARPMENT AT THE INDIAN LADDER AND EASTWARD. LOOKING SOUTH.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Preliminary Report on the Geology of Albany County.

By N. H. DARTON.

PHYSIOGRAPHY.

JAMES HALL, *State Geologist:*

SIR.—Albany county, in central eastern New York, has an area of approximately 550 square miles. It has a frontage of about twenty-four miles on the Hudson river from north of the Mohawk river to below Coeymans Landing, and extends about twenty-five miles westward. It is bounded on the south by Greene county, on the west by Schoharie county, on the north by Schenectady and Saratoga counties, and on the east by the Hudson river which separates it from Rensselaer county. It is separated from Saratoga county by the Mohawk river.

Topographically the country comprises three principal provinces ranging in altitude from tide water along the Hudson river to 2200 feet to the southwestward. They are, first, the elevated plain extending from the banks of the Hudson and Mohawk rivers over the eastern and northeastern townships, to a line passing from near Coeymans Junction through Altamont, with an area approximately of 200 miles; second, the Helderberg escarpment, a line of high cliffs arising abruptly from the plain, along its western margin and surmounted by a plateau and terraces of variable width; third, a wide area of high rolling hills and terraced ridges presenting a steep front to the plateaus above the escarpment. This occupies an area of about 175 square miles, extending to the southwestern corner of the county, where ts hills finally merge into the long slope of the northern extension of the Catskills. In the northern part of Knox township there is a region of hills extending northward from the foot of the crest of the great escarpment to Schenectady county, and there are some elevations of the same nature in the central part of New Scotland township.

The great plain.— The great plain extending from the foot of the Helderberg escarpment to the rivers (Hudson and Mohawk) presents wide areas of comparatively smooth surface, having an altitude sloping gradually from 200 feet about Coeymans Junction to 300 feet in the northeastern corner of the county and 400 feet toward Altamont. The streams which traverse this plain are the Normanskill, Vlaumankill, Coeymans creek and Patroon's creek. These streams, and their branches, have cut valleys of various kinds, which are in greater part relatively narrow and steep sided. The plain extends up the Oniskethau and Hannacrois valleys for a considerable distance, and up the Boxenkill to a point two miles above Altamont. About Wemple the higher plain is separated from the Hudson river by a terrace averaging 100 feet above tide, but in the other parts of the region it ends in steep banks bordering the Hudson and Mohawk valleys. These terrace scarps rarely extend to the shore of the river, but rise from a low alluvial plain which occupies a greater or less width in the bottom of the depressions. The city of Albany is built, in greater part, on the slope of this terrace scarp, and along the low narrow terrace at its base. The upper part of the city is on the high plain, at an altitude of from 180 to 240 feet above the river. The surface of the great plain is diversified by a considerable number of hills and ridges rising above its surface. The more conspicuous of these are located mainly north of the latitude of Albany, where they are scattered about irregularly, and give rise to a peculiarly knolly topography. They seldom rise more than fifty feet above the general plain, and present smooth surfaces, except where they are cut by streams.

The Helderberg escarpment.—The Helderberg escarpment is the most conspicuous topographic feature in Albany county. It rises with great steepness at the western margin of the plain above described, and its precipitous level-crested front is visible for many miles to the east and north. Its greatest development is between Altamont and New Salem, where it finally attains an altitude above the plain of 1200 feet. This elevation is in the eastern face of Countryman hill, opposite New Salem, and is attained in a series of strongly-marked terraces. The escarpment enters Albany county from the westward with less distinctness than it usually presents, owing to a great mass of drift which lies against its face. Its prominence rapidly increases in the central part of Knox township, but its elevation and steepness are variable. To the north it descends to the Boxenkill valley in long slopes surmounted by a more or less distinct precipice at all points. South of Altamont the cliffs increase in height, the slopes rapidly shorten, and the escarpment turns abruptly southward, presenting a mural front 800 feet in height to the eastward. At several points it is recessed, notably at the Indian Ladder, where a magnificent amphitheater has been cut by the little stream which falls over a limestone cliff at the top. The principal features of the escarpment in this vicinity are shown in plate 1.

West of Indian Ladder the escarpment is surmounted by a series of wide plateaus extending far back into the country as shown very plainly in the plate. To the south of Indian Ladder these plateaus and the range of high hills of the third province extend eastward to the edge of the escarpment and a maximum elevation of 1634 feet is attained in Countryman's hill. To the south of New Salem the mass of high hills recede, the terraces expand and the southward dip of the rocks gradually carries the escarpment down to a very moderate degree of prominence. In the central part of New Scotland township its course becomes irregular and it extends to the southward in a series of abrupt offsetting trends to the eastward. In this region there lie in front of the escarpment a series of moderately elevated ridges which here mark the western border of the plain.

South of Feurabush the escarpment increases in altitude, and extends eastward to the margin of the plain of which it thence constitutes the western boundary to the southeastern corner of the county. It here presents its usual characteristics of long walls of limestone cliffs, but the altitude above the plain here averages only about 200 feet. Opposite South Bethlehem the escarpment is broken through by Oniskethau creek and the Spraytkill.

In New Scotland and Coeymans townships the plateaus and terraces above the Helderberg escarpment have a width varying from two to four miles. They present a considerable variety of surface features owing to the erosion to which they have been subjected by the Oniskethau and Hannecrois creeks and their branches. These streams have cut irregular valleys of considerable width across the terraces and isolated a number of abrupt ridges, especially to the southward.

Southwestern townships.— The highly elevated region of the southwestern third of the county presents a great variety of topographic form. Its general character is a high plateau deeply and widely invaded by a complex system of valleys which have reduced the greater part of the area to a series of slopes. A noteworthy feature of the region is the very steep front which it presents to the north and to the east, which rises from 400 to 500 feet abruptly from the upper terrace behind the Helderberg escarpment. This front extends almost due east through the northern part of Berne township and then turns abruptly southward and extends along the eastern front of the Helderberg mountains to Clarksville. South from Clarksville, in Bennett, Copeland and Blodgett hills, it offsets to the eastward in a series of ridges very abruptly terminated northward. A reference to the topographic base map accompanying this report will, I believe, be the most satisfactory means of forming a conception of the nature of these curious offsets.

The hills of this southwestern region increase in altitude to the north and west from about 1000 feet in Coeymans township to 1700 feet in the northern part of the Helderberg mountain, and over 2000 feet west of Rensselaerville. To the north the region is deeply invaded by the Switzkill, which has cut a deep, steep-sided valley extending far southward. From the west it is invaded by the Little Schoharie creek, from the south by several important branches of the Catskill, and from the southeast by Hannecrois creek. These drainage systems quite widely overlap each other in the central part of the region, and the main stems of their upper waters are in greater part separated by divides which are considerably lower than the adjacent hills. The most noteworthy of these low divides is north of Rensselaerville, where the elevation of the divide between the Switzkill and Ten-Mile creek is approximately 1480 feet, while the surrounding hills have an altitude of about 300 feet more.

The divide between Little Schoharie creek and Ten-Mile creek is at about 1700 feet above tide, which is considerably below the level of the adjacent hills. This feature of low divides is general throughout the region, as reference to the topographic base of the geologic map will show.

Along the steep eastern front of the region there is considerable invasion by small streams, mainly by the head-waters of Oniskethau creek, which cuts across the ridge of the Helderberg mountain, and by some branches which head behind Bennett, Copeland and Blodgett hills.

A very large part of the region presents a terraced surface due to alternations of hard and soft beds.

General Structural Relations.

The general geologic structure of Albany county is indicated by the section in figure 1.

Fig. 1.

FIG. 1.—Section from southwest to northeast through Albany county exhibiting the general relations. N., Oneonta formation; H., Hamilton flag series; M., Hamilton shales; O., Onondaga limestones; E., Esopus slates, Oriskany sandstone, etc.; P., Lower limestones of the Helderberg series; R., Hudson river formation; C., Clay and sands on glacial drift. Horizontal scale, four miles to one inch. Vertical scale and rate dip greatly exaggerated.

This section shows a great succession of beds of various rocks dipping gently to the southwestward, excepting in the vicinity of the Hudson where there is much disturbance. The wide plain of sand and clay extending west from the Hudson river is underlaid at a greater or less depth by the members of the Hudson river formation. The great cliffs of the Helderberg escarpment are due to the overlying Helderberg limestones, notably a medial member of the series, and the terraces and plateaus beyond, to alternations of limestones, shales and sandstones. A great series of overlying shales and flags constitute the high region which rises abruptly to the south and west and extends to the foot hills of the Catskills. In this wide area of highlands, higher beds come in succession to the southwestward.

There is considerable variation in the relations of the terraces and plateaus behind the crest of the Helderberg escarpment and in the nature of this escarpment, but they are all clearly shown on the geologic map and described in the following pages. In the northwestern corner of the county the Hudson river members of the series rise into high hills which extend to the Helderberg escarpment southward, a feature which is general for many miles west of Albany county but ends abruptly in the northern part of the Helderberg mountain.

In the southeastern corner of the county the Helderberg and overlying formations extend into the disturbed belt adjoining the Hudson river, and are flexed and faulted to a considerable degree.

Stratigraphy.

The stratigraphy of Albany county has been comparatively well known for over half a century. In 1820 Prof. Eaton* published a report in which the more prominent features were outlined, and the later studies by Mather† and Hall‡ of the Geological Survey, have afforded knowledge as to the character, age, palæontology and relations of the principal formations.

In the following descriptions I shall give a resumé of the principal characters of the formations extended somewhat by new information regarding local features and distribution.

* Amos Eaton and T. R. Beck. A geological survey of the county of Albany, 56 pages, 8vo Albany, 1820.

† Geology of New York. Part I. Comprising the geology of the First Geological District. Albany, 1843.

‡ Palæontology of New York, and many papers on New York geology.

The rocks in Albany county are the Hudson river slates and sandstones, and members of the upper Silurian and Devonian from the Salina to the Oneonta. They are as follows:

	Thickness. Feet.
Oneonta, red shales and flaggy sandstones	1000
Hamilton flags and shales	700
Hamilton black shales	600
Onondaga limestone	70
Schoharie grit	6
Esopus shales	100
Oriskany sandstone	4
Becraft limestone	15
Shaly limestone	100
Pentamerus limestone	65
Tentaculite limestone	30
Salina waterlime	4
Hudson river shales and sandstone	3500

There are also wide areas of sand and clay and many deposits of glacial drift. The Oneida, Medina, Clinton and Niagara formations are lacking, possibly the Niagara formation exists at some points in the base of the Helderberg escarpment under the drift and talus.

Oneonta formation. — This formation has not before been differentiated in Albany county, but I have traced it continuously from the typical region eastward and find that it is extensively developed. It consists of a series of flaggy sandstones with intercalations of red shales which cover the elevated regions of the southwestern corner of the county in Rensselaerville and Westerlo townships. It is cut through by the valley of Ten-Mile creek, which separates the high regions west and south of Rensselaerville. The red shales are a conspicuous feature of the formation and are extensively exposed throughout its area. They constitute beds of from one to thirty feet in thickness, intercalated at irregular intervals among dark-gray, flaggy sandstones. There are also in the formation, beds of red sandstone and thin beds of dark-gray or black shales, but they are of infrequent occurrence and of no great thickness. The beds of red shale appear to be continuous over wide areas, but in some cases, at least, they thin out and give place to slabby sandstones. Their materials do not merge into those of the enclosing members, and they appear to be separated, in most cases, by slight local unconformities. The red sandstones are hard, moderately coarse-grained, thick-bedded quartzitic rocks, and it is thought that they do not represent a definite horizon. The region occupied by the Oneonta formation in Albany county is much obscured by accumulations of drift, which render precise determination of stratigraphy a matter of great difficulty. There are, besides, rapid changes in the character of the beds, which give rise to considerable dissimilarity in sections of the same series made at any great distance apart. From the northeastward the first exposures of the Oneonta formation are near the summit of the high ridge east of Rensselaerville, where the red shales outcrop along the road and in the adjacent fields over a narrow belt. This belt widens to the southward and covers all of the high region along the Westerlo-Rensselaerville boundary. Owing to very heavy drift cover in this region, exposures are neither frequent nor extensive, but there are many small showings of the red shales and flaggy sandstones in various stream and road cuts.

In the highlands northwest of Rensselaerville the Oneonta formation thickens rapidly and is spread out over a wide area extending far into Schoharie county. The red shales and associated beds are seen in a limited area north of the headwaters of the Little Schoharie creek, the valley of which cuts through to the underlying formations. In the southern part of Rensselaerville township the formation is very extensively exposed in the deep valleys and along the hill slopes which characterize this region. Above Preston Hollow the Catskill creek cuts through two members, which belong apparently to the underlying series, but about Preston Hollow and below, the banks exhibit the red shales and associated beds of the typical Oneonta, although not far above its base. The surrounding hills rise to an altitude averaging about 1000 feet above the bottom of the Catskill creek valley, and consist of the characteristic succession of red shales and gray flaggy sandstones. Exposures are abundant in this region, although there are areas of drift which hide the formation at some localities.

The maximum thickness of the Oneonta formation exposed in Albany county is about 1000 feet, but there are higher beds of the formation to the southward in the northern front of the Catskills. In mapping the Oneonta formation in Albany county I have assumed that its base was at the bottom of the lowest red shale member, because this was the only distinguishing feature that I could use as a guide. Probably this horizon will prove, on detailed examination, to be somewhat variable, but I believe not with very wide limits.

Hamilton flags and shales.— Underlying the Oneonta formation there is a great series of thin-bedded sandstones of various kinds, with intercalated beds of dark-colored shales The flaggy members are the more prominent because they give rise to conspicuous outcrops and to a characteristically terraced topography. The shales constitute about an equal proportion of the series, and give rise to the slopes between the terraces. The flags are dark-gray, moderately fine-grained sandstones varying in thickness from one-half inch to three inches, and in greater part separating readily along their bedding planes. They have been quarried to a considerable extent for the market, and are highly esteemed for flagging. The thickness of the beds of flags is exceedingly variable, ten to fifteen feet is frequent, but there are beds which have much less thickness. It is found that in part some of the flag beds give place to black shales and they also vary considerably in thickness of bedding, in texture and in color in the same bed. The intercalated shales are in greater part moderately hard, dark in color, and have a thickness ranging from fifteen feet to a few inches. No definite stratigraphy was made out in the flagstone belt, owing to considerable obscurity of outcrops by drift and the frequent changes in the character of the deposits. The amount of workable flagstone in the series is very great, but on account of the distance from adequate means of transportation and the consequent great expense of hauling, it is now practicable to work only those beds which yield stone at the very least cost. Owing to the variability in the character of the flags, and to the presence of large amounts of waste material which has to be stripped, there are many areas underlaid by excellent flagstone which cannot be profitably worked. This is particularly the case on steep slopes, where the flags dip into the hill. The beds of flags are not at any definite horizon, although the greater amount of flag which has been worked is from beds about 250 feet above the base of the series. The principal quarries are between Rensselaerville and South Berne, at Reidsville and at Dormansville. There are many small quarries scattered about at various localities. The quarries between Rensselaerville and South Berne are in a bed about twelve feet thick, which is relatively uniform in character throughout, and has yielded a valuable product. The Reidsville quarries have been worked in several beds, constituting a local series, about twenty-five feet thick. The Dormansville quarries are in a bed about ten feet thick, which yielded a very large amount of excellent flagging. The region occupied by the flag series is deeply trenched by the Switzkill, which cuts through into the underlying shales. It extends southward into Greene county and the deep valley of Ten-Mile run and are finely exposed at the falls at Rensselaerville and end in the gorge above. They are widely removed in the region adjacent to the Hannacrois creek, but there are outliers along the higher summits of the Helderberg mountains, in the high area west of Countryman hill, and in the higher summits of Koong and Blodgett hills, which all appear to belong to this series. The basal line of the formation has been drawn at the bottom of the lowest heavy bed of flags which appears to be a relatively constant horizon over a wide area, although its stratigraphic position may vary somewhat. The thickness of the series is about 700 feet. It dips south-southwest in Berne township, and to the southwest in Westerlo township. There are local variations in the direction and amount of dip but they were not studied in detail.

The lower portion of the formation is sparingly fossiliferous, particularly some of the softer thinner flags, which yield a Hamilton group fauna. The upper beds of the series may extend above the limits of the Hamilton group of western New York, but I have at present no definite evidence on this point.

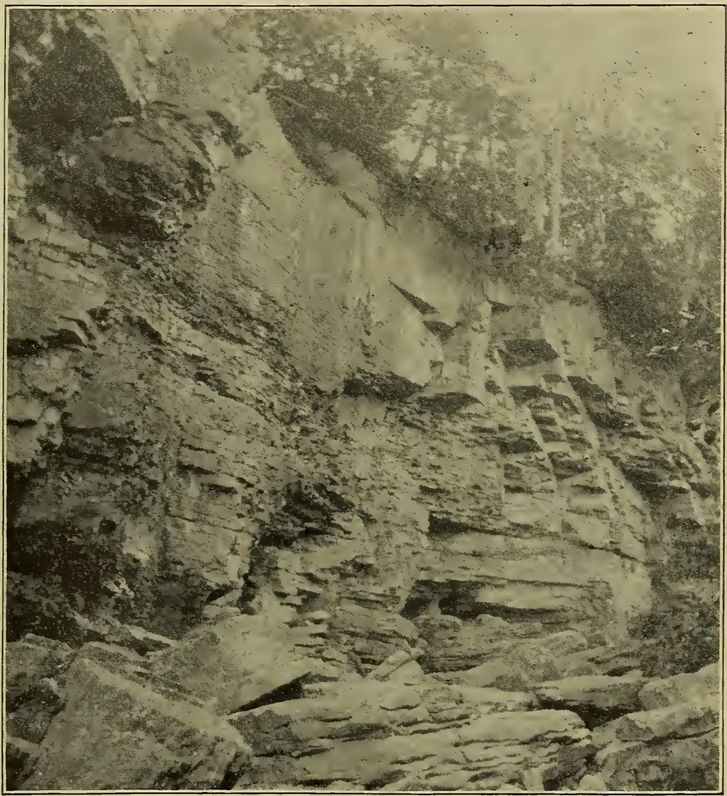
The Hamilton black shales.— This formation comprises 600 feet of argillaceous deposits lying between the flagstone series and the Onondaga limestone. It constitutes the steep northern and eastern slopes south and west of the Helderberg escarpment, and is a surface formation over the wide area in western Coeymans township drained by Hannecrois creek, deeply excavated by the Switzkill, up which it extends southward nearly to South Berne, and it occupies a wide area of moderately high land extending north from East Berne. It consists in greater part of shales, hard above and softer below, with occasional thin, intercalated beds of flaggy sandstones among its upper members. Its basal beds are in some places so dark that they have been mistaken for coal, and many attempts have been made to work them for coal. Their dark tint is due to the presence of a very large amount of carbonaceous material, which in some cases will burn for a few minutes when the shale is put in the fire. There are, however, as every geologist knows, no beds of coal in this formation, and all attempts to obtain coal therefrom will be futile. The shales of this formation are abundantly fossiliferous in certain beds at various horizons, and, as well known, contain the fauna of the lower Hamilton group.

Onondaga limestone.— This formation gives rise to a terrace of greater or less width extending along the foot of the steep slopes of the Hamilton shales. In the northeastern face of the Helderberg mountain its outcrop is very narrow, in some places not over 100 feet. Westward, it widens to a mile and a half about Thompson's lake, then is contracted again by the northern extension of the Hamilton formation north from East Berne, west from which it widens to nearly three miles in the long slopes northwest of Berne. It is spread out over a considerable width about Clarksville and Oniskethau creek. At the north end of Copeland and Blodgett hills it is narrowed to 200 yards, constituting a very distinct shelf, on the relatively smooth surface of which the road passes for several miles. A mile east of Clarksville there is a small outlier of the formation, which is a very unusual feature. There is also a small outlying area on top of the ridge three miles south by west of South Bethlehem.

The surface of the formation is much obscured by drift in some districts, notably in the wide area north of Peoria where outcrops are exceedingly rare on this account.

The formation consists of a light blue gray, sub-crystalline, tough, massively-bedded, pure limestone containing lenses of chert in courses and irregularly disseminated. In the bed of a

PLATE 2.



Lower Members of the Onondaga Limestone on Oniskethau Creek at Clarksville.
Looking Southwest.

small creek a few rods west of Peoria (West Berne), the upper beds are seen to consist of a very dark, coarse, crystalline limestone, quite closely resembling black marble in appearance. It is apparently of local occurrence, for I have not observed it elsewhere. The occurrence of chert in the formation is very irregular, but it is in largest amount in the lower beds. In some localities it is almost altogether absent, but this is unusual. Thin intercalations of shale occur at some localities, but they, also, are exceptional features. The limestones are fossiliferous to a variable extent. The principal fossils are comprised in beds consisting largely of corals which occur in some places. The most notable outcrops of beds of this character are along the road a half mile northwest of Thompson's lake, where the corals are so numerous that the bed may properly be designated a fossil coral reef. In the bed of the Foxkill, at Peoria, corals also occur in abundance, constituting a large portion of the beds of limestone here exposed. There also occur other fossils than corals, and these are present in greater or less amount at almost every locality, although they are not conspicuous. One of the finest exposures of the formation in the county is in the cliffs along Oniskethau creek, at Clarksville. In plate 2 there is given a view of the general appearance of a portion of this exposure.

The occurrence of many sinks in the Onondaga limestone is a noteworthy feature. These are depressions in which the drainage of a greater or less area disappears into fissures or caves in the limestone. Thompson's lake is the most notable of these, and there are several smaller sinks southeast of Thompson's lake and another at a point two miles north-northeast of Berne. In the limestone shelf along the eastern face of the Helderberg mountain, Bennett, Copeland and Blodgett hills, there are many small sinks at or near the margin of the Hamilton shale, which are a conspicuous and characteristic feature of this formation.

Schoharie grit.— This formation has not been separately represented on the map owing to its restricted occurrence. It is well characterized at Clarksville and for several miles in that vicinity, but elsewhere in Albany county it appears to be absent. It is a very impure limestone, which weathers at the surface to a dark buff, spongy, sandrock, containing an abundance of characteristic fossils. It merges into Onondaga limestone above, but is quite sharply separated from the underlying Esopus shales. The greatest thickness observed was six feet in an exposure along the road on the slope three-fourths of a mile south of Callanan's Corners. At Clarksville the amount is considerably less, and along the road at the base of Countryman hill it is apparently not over a few inches. In the intervals between these three exposures, I found no outcrops. To the north and west there are a few exposures of the base of the Onondaga limestone, in which the Schoharie grit is seen to be absent, and this appears to be the case in the southeastern corner of the county, although critical exposures were not found.

Cauda-galli grit=Esopus slates.—This formation consists of dark-colored, sandy shales, which, to the southward, have a pronounced slaty cleavage. In the Helderberg mountain and westward these shales give rise to the slope extending from the terrace of Onondaga limestone above to the terrace of Oriskany sandstone below, a feature which is very characteristic. In the flexed region south of South Bethlehem the formation is spread out over an area of considerable width, in which it gives rise to very sharp ridges with abrupt slopes and barren aspect. The sharpness of these ridges is due in the main to increased hardness of the formation and the development of slaty cleavage, which characterizes the formation from this district southward. In color the shales are in greater part very dark gray, which weathers somewhat lighter on long exposure. The finest exposures are in the ridges south of South Bethlehem, in the gorge of the Onisketbau at Clarksville and below, at several points along the eastern face of the Helderberg mountain, and at intervals westward by Knox. It extends several miles southward in the north fork of the Foxkill, being finely exhibited in a short gorge a mile due north of Berne and apparently extending to within a short distance of that village. The thickness of the formation averages about 100 feet in Albany county. The formation exhibits on its bedding planes, wherever these are exposed, impressions of a fucoid known as *Spirophyton caudi-galli*, or the "cock-tail fucoid." These impressions are most distinct where the beds are slightly quartzitic, a feature not unusual near the upper part of the formation. The finest exposures that I have seen of this stratum are at Clarksville in a small inlaying area exposed in the stream cut just south of the center of the village.

Oriskany sandstone.— This is a very thin bed of hard sandstone or quartzite which is continuous over a wide area. Owing to its hardness it usually gives rise to an outcrop of considerable width constituting a well-defined shelf, at the base of the slopes of Esopus shale. This shelf bears in some parts of the area masses of glacial drift and the formation is completely hidden by this material near the western margin of the county and at several points in the Onisketbau valley. Between Knox and Indian Ladder the formation affords a hard, even bed for the roads for considerable distances, and its exposures along these roads are very characteristic. For several miles south from Callanan's Corners the formation appears to be absent, as several exposures were examined in which the Esopus shales appeared to lie directly on the Becraft limestone. It comes in again west of Coeymans Junction, where it is exposed at several points at the base of the easternmost ridge of Esopus shales. The formation is in greater part calcareous, but the amount of lime which it contains is variable. Usually there are beds which are very calcareous and weather to a porous buff sandrock filled with characteristic casts of the fossils; and these are conspicuous in nearly every exposure. The thickness varies from one to four feet and averages about three feet over the greater part of the area.

Becraft limestone.—This is the uppermost member of the Helderberg limestones. It is a light-colored, coarsely semi-crystalline rock in thick beds. It is highly fossiliferous, consisting in considerable part of replacements of fossils. The most conspicuous of these are the cups or pelves of a crinoid, having in greater part a diameter of from one to two inches. The white calcite by which these remains are now represented contrasts strongly with the light bluish-gray of the containing limestone and are a distinguishing feature throughout. Its thickness averages about fifteen feet, but at some points it appears to be slightly less. It usually gives rise to a low cliff capped by the Oriskany sandstone; its finest exposures are in the vicinity of Knox, but it is also frequently seen in the Helderberg mountain and in the vicinity of Clarksville. Between Onisketbau and Callanan's Corners it is in greater part covered by drift. It comes out again in the creek bed just south of Callanan's Corners and at various other points in the vicinity. South of South Bethlehem it extends over a considerable area in the flexures which traverse that district, particularly along the base of the steep ridges of Esopus shales. Its relations in this region are shown on the section in plate 5.

Shaly limestone.— The Becraft limestones are underlaid by a series of thin-bedded, very impure, highly fossiliferous limestones, containing many shaly intercalations, and varying in color from gray to gray brown. As is the case with the Esopus shales, they are regularly bedded westward, but in the flexures south of South Bethlehem they are traversed by more or less slaty cleavage, and become considerably harder. In the Helderberg mountains and westward they constitute the slopes or gently rolling plateaus above the Pentamerus ledges, but to the southward they give rise to sharp ridges covered with rugged ledges, in some cases closely resembling the lighter-colored outcrops of Esopus shales. In the high ridge between Clarksville and Stony Hill there are several outliers of the formation. The thickness of the Shaly limestone averages 100 feet throughout.

Pentamerus limestone.— This is the most conspicuous member of the Helderberg formation, for its outcrop is marked by extended lines of prominent cliffs, in most cases surmounting long slopes of the underlying formations. In the few valleys by which it is crossed it gives rise to falls. The formation consists of hard, very massively-bedded limestone of bluish-gray color, weathering to a somewhat lighter tint. The beds are traversed by vertical jointing, and this character, together with the presence of softer underlying beds, gives rise to the cliffs which characterize its outcrop. Besides the thick regular bedding there is also an irregular sub-bedding into flat, interlocking lenses and corrugations, the outlines of which are brought out by weathering. Occasional shale partings occur, and also nodules and thin lenses of chert. The thickness averages sixty-five feet throughout Albany county. Owing to its hardness the formation is almost everywhere exposed, but the finest exhibition is in the northern and eastern face of the Helderberg mountains, where it presents the appearance represented in plate 1.

Cliffs of Pentamerus and Tentaculite Limestone at the Indian Ladder, Albany County, N. Y. Looking Southwest.

In Knox township the cliffs of Pentamerus limestone vary considerably in elevation, but they are continuous throughout. At several points in the western part of the township there are heavy masses of drift piled against the cliffs, but they are not entirely buried. At the Indian Ladder the cliffs expose the entire thickness of the formation, together with the underlying beds. A view of this feature is given in plate 3.

In the ridges east of Clarksville the formation occupies an area of considerable width along the crests, and extending down their western slope to the Oniskethau creek. The cliffs trend to the eastward along portions of their course in this region, and the escarpments presented northward are heavily flanked by drift. From Feurabush southward the Pentamerus cliff has considerable prominence, except for a short distance west of South Bethlehem, where it is crossed by the low gap between Oniskethau and Sprayt creeks. South of here the line of cliffs is continuous to the gap cut by the Hannacrois creek in Greene county.

Tentaculite limestones — These are thin-bedded, dark-blue limestones lying below the Pentamerus beds and usually outcropping in the base of the Helderberg escarpment or lying beneath its talus. The strata vary in thickness from an inch to a foot, in greater part, but two or three inches is the general average. There are occasional intercalations of shaly beds. In the upper members, in most localities there is a thin bedding or ribboning of alternating lighter and darker tints, which is the "ribbon limestone" of some writers. Toward the base of the series there is usually a more massive bed containing *Stromatopora*, but the member is not conspicuous in Albany county in its typical development.* The Tentaculite beds have a thickness of about thirty feet along the eastern face of the Helderberg mountain, and this appears to be the average thickness throughout.

The beds are frequently exposed at intervals along the Helderberg escarpment. They outcrop at several points southwest and south of Altamont, at the Indian Ladder, southwest of New

*This Stromatopora bed is excellently exposed on the Albany and Schoharie plank-road beyond Altamont; also about two miles west of the road from Albany to Clarksville on the land of Mr. Merkel, and on the same road two miles northeast of Clarksville. There is also a good exposure on the slope of the hill at Coeymans Junction, both on the roadside and in an extensive quarry. Most of these exposures show that the bed lies but a few feet below the Pentamerus limestone.— H.

Salem, and about South Bethlehem. A mile and a half southwest of South Bethlehem they are brought up by a small anticlinal and exposed over an oblong area surrounded by the Pentamerus beds. They are extensively exposed in the road-metal quarry at South Bethlehem surmounted by the lower beds of the Pentamerus limestone, as shown in plate 4.

Salina waterlime.— This formation is represented in Albany county by a few feet of waterlime beds, which may not be continuous throughout. Only two distinctive exposures were found: one at the Indian Ladder, and the other in the floor of the quarry at South Bethlehem. The thickness in both cases is about four feet. The beds are impure, magnesian limestones, in three or four layers with some shaly intercalations. The upper surface of the series in the quarry is characterized by a reticulation of sun cracks, which are usually distinctive of this horizon. There is apparently no cement included, so far as I could ascertain from these two exposures.

The unconformity.—At the base of the Salina formation there is an unconformity representing the early part of upper Silurian times. It is an unconformity which is general in eastern New York but appears to give place to a continuous succession in the western part of the State and to the southward from central Pennsylvania. In Albany county there was apparently no deposition of Niagara, Clinton, Medina or Oneida formations, but it is possible that they were deposited in attenuated form and then removed by erosion. The principal feature of the epoch was a general uplift of the Hudson river sediments without material flexing westward but with considerable disturbance in the vicinity of the Hudson river valley and eastward.

In the Helderberg mountains and westward the Salina and Helderberg limestones lie on the Hudson river formation without appreciable unconformity in dip. To the southeastward, in the region where the Hudson river and overlying formations are flexed, there is a prominent unconformity in dip. There are excellent exposures of the contact at Indian Ladder, at a point a mile due south of New Salem, on Sprayt creek, at the road metal quarry south of South Bethlehem and near the road a mile southwest of Coeymans Junction.

PLATE 4.

Tentaculite Beds with Lower Portion of the Pentamerus Limestone, Road-metal Quarry, South Bethlehem. Looking South.

The Hudson river formation.— The Hudson river formation consists of dark shales with interbedded, very fine-grained, massively-bedded sandstones, which are frequent in the upper members but thinner and less frequent below. In the lowest beds there are intercalations of black carbonaceous slates containing a well-known graptolite fauna.

A greater part of the wide area occupied by this formation is overlaid by Champlain deposits, and it constitutes the surface only in the hills west of Altamont, along the lower slopes of the Helderberg escarpment and along or near the Hudson and Mohawk rivers. There are fine exposures above Altamont where the Boxen Kill has cut a ravine through the formation; and there are extensive outcrops in "gulfs" in the Indian Ladder region. In the banks of the Mohawk there are frequent exposures, notably at the great falls at Cohoes. Along and near the Hudson there are scattered outcrops of which the most extensive are on the lower Norman's Kill at Kenwood and on the West Shore railway along the scarp of the second terraces from "The Abbey" to Wemple. Within the area of the great plain of Champlain deposits exposures are rare, for the streams seldom cut through to the slates. The exposures along the Spraytkill, southwest of South Bethlehem, are the best that I observed. They extend from the fault to the vicinity of the road-metal quarry.

The graptolitic beds are exposed at Kenwood and along the railroad a short distance south of "The Abbey." They appear to constitute the lowest members in Albany county, but the structure in this region is so complicated by intense folding, accompanied by crushing and faulting, that the relations were not apparent. The black graptolitic slates, gray slates and shales and sandstones are intermingled in the most complex manner and extended observations will be necessary to unravel the relations.

The thickness of the Hudson river formation is not less than 3480 feet, at least in the region near Altamont. This estimate is based on the record of the gas wells bored near Altamont in 1886, which, according to Ashburner,* penetrated 2880 feet to the Trenton limestone. I find that there are about 600 feet more

* Petroleum and natural gas in New York State; Am. Inst. Mining Engineers. Trans., vol. 16 pp. 906-953, plates. 1889.

of the formation up to the Helderberg beds in the slope southward, which gives a total of the thickness of 3480 feet.

Structure.

The general structure of Albany county is represented in figure 1. In the following statements an account will be given of the exceptional features of the structure.

The monoclinal region is relatively uniform in relations. There are many slight local variations in the amount and direction of dip, but these are more apparent in their general effect on the distribution of formations than in local outcrops. The two sections in the following figure represent the principal features in the vicinity of the Helderberg escarpment to the northwestward.

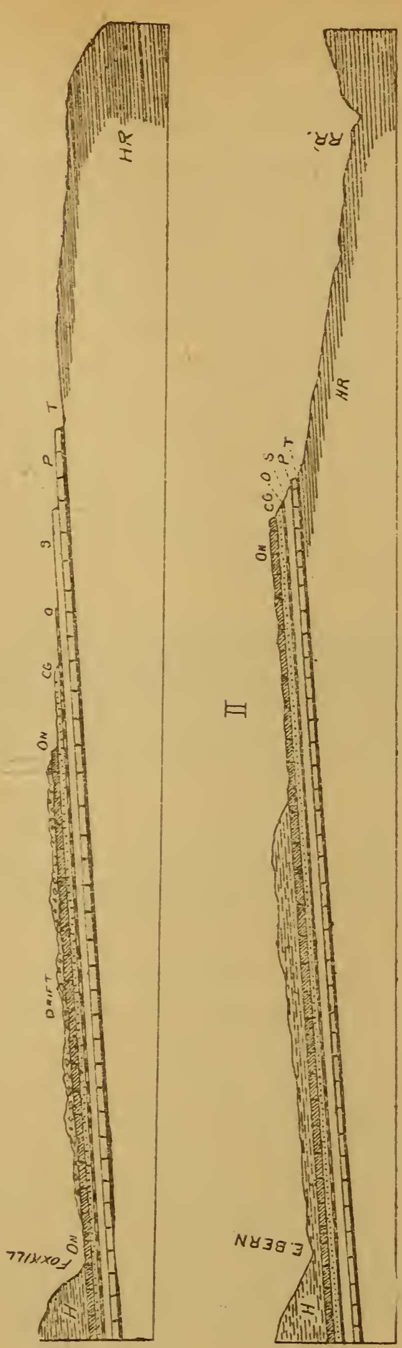


Fig 2

Fig. 2 represents the Helderberg escarpment and vicinity in the northwestern part of Albany county; H., Hamilton shales; On., Onondaga limestone; C.G., Esopus shales; O., Oriskany sandstone; S., Becraft and Shaly limestones; P., Pentamerus limestones; T., Tentaculite and Salina beds; H.R., Hudson river formation.

In section I the amount of dip appears to be not over 100 feet to a mile. Here the Onondaga limestone is bared over a wide area, and the underlying formations outcrop in succession northward in broad terraces. They are, however, heavily drift covered and there are too few outcrops on which to base a satisfactory determination of structure. In section II, the dip is about the same or slightly less and the Hamilton shales are seen extending to within a mile of the Helderberg escarpment, with the underlying formations occupying narrow belts in the slopes below. To the eastward about Thompson's lake and Indian Ladder the dip is reduced to an amount not over thirty-five feet per mile, but there is some evidence that it is more variable in this section than it is to the westward. The following figure is along the eastern face of the Helderberg mountains and exhibits the structure of this great escarpment, which is such a conspicuous feature in Albany county. In this vicinity the southerly dip gradually changes to the southwestward and decreases in amount.

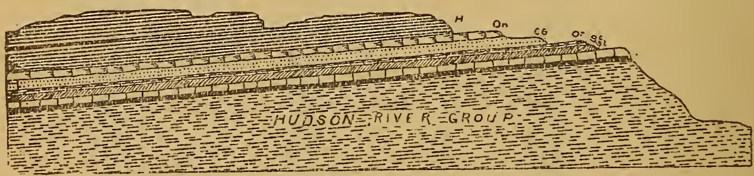


Fig. 3

Fig. 3.—Section along the eastern face of Helderberg mountains, in the vicinity of New Salem. Scales: Vertical, 1600 feet to one inch; horizontal, 4000 feet to one inch; H., Hamilton; On., Onondaga limestone; CG, Esopus shales; Or., Oriskany; Sc., Becraft limestone; Sl, Shaly limestone; P., Pentamerus limestone; T., Tentaculite beds and Salina waterlime. Looking west.

The succession of rocks is superbly exposed in the eastern face of this great escarpment as a series of terraces, from the Hamilton at the top, to the long slopes of Hudson river shales and sandstones below; the principal terrace scarps being marked by the Onondaga limestone, Oriskany sandstone, and Pentamerus limestone with adjoining formations in the intervening slopes. The dip averages 112 feet per mile and south ten degrees west in direction. This carries the outcropping edges of the formation gradually downward along the face of the mountain, from an altitude of 1100 feet above tide south of Altamont to about 1000 at Indian Ladder and 660 feet a mile south of New Salem. To the southward about Clarksville, the rate of dip gradually decreases to sixty feet per mile, and its direction changes to due west. As the formations of the Helderberg mountains are brought down to the general country level, they extend to the east and south into a flexed region. The first features noticeable are a series of gentle undulations which broaden the outcrop areas of the limestones and indent their edges into a series of *en echelon* offsets. These undulations enter the Helderberg area in succession from

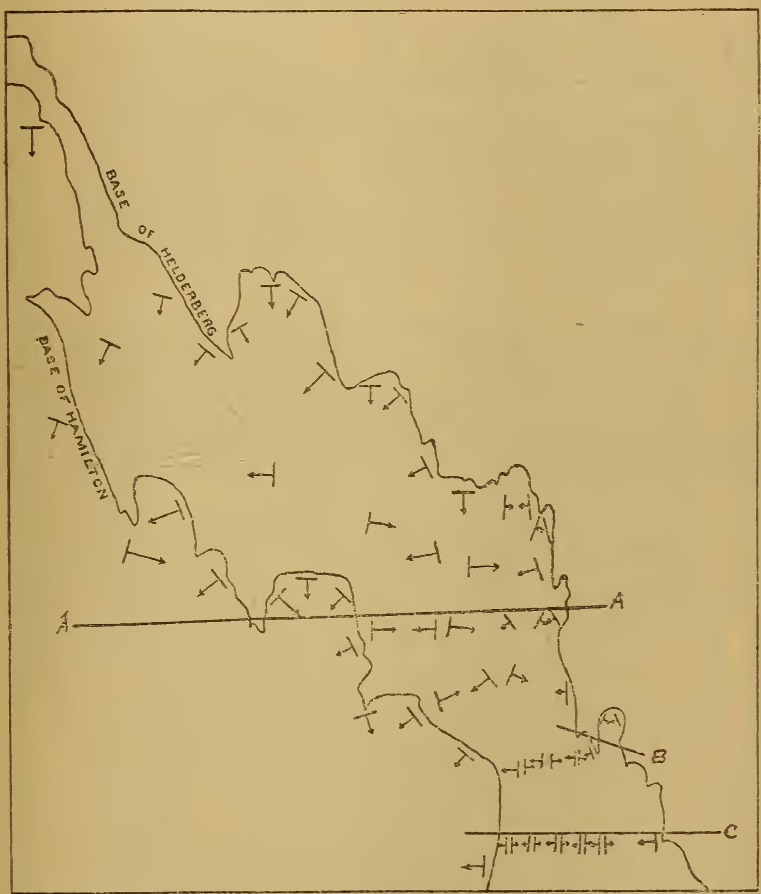


Fig. 4

FIG. 4 — Diagram of a portion of Albany county to illustrate the undulations at the edge of the folded region, from New Salem southward. Scale, two miles to one inch. The length of the stems of the dip marks is inversely proportional to the amount of dip. A-A. Section given in figure 5. B. Section in figure 6. C. Northern section on plate 5.

west to east, as it extends southward, along axes striking south ten degrees west, approximately, and pitching slightly in the same direction, which is diagonal to the general inclination of the monocline. In figures 4 and 5 I have attempted to illustrate the nature of these features in the limestone area, for they are an interesting example of the beginning of the series of flexures, and they explain the singular distribution of the Helderberg rocks in this portion of Albany county.

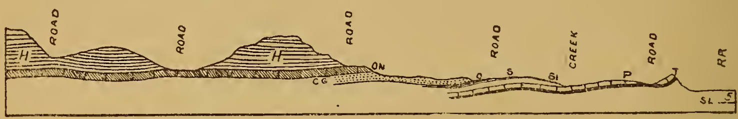


Fig. 5

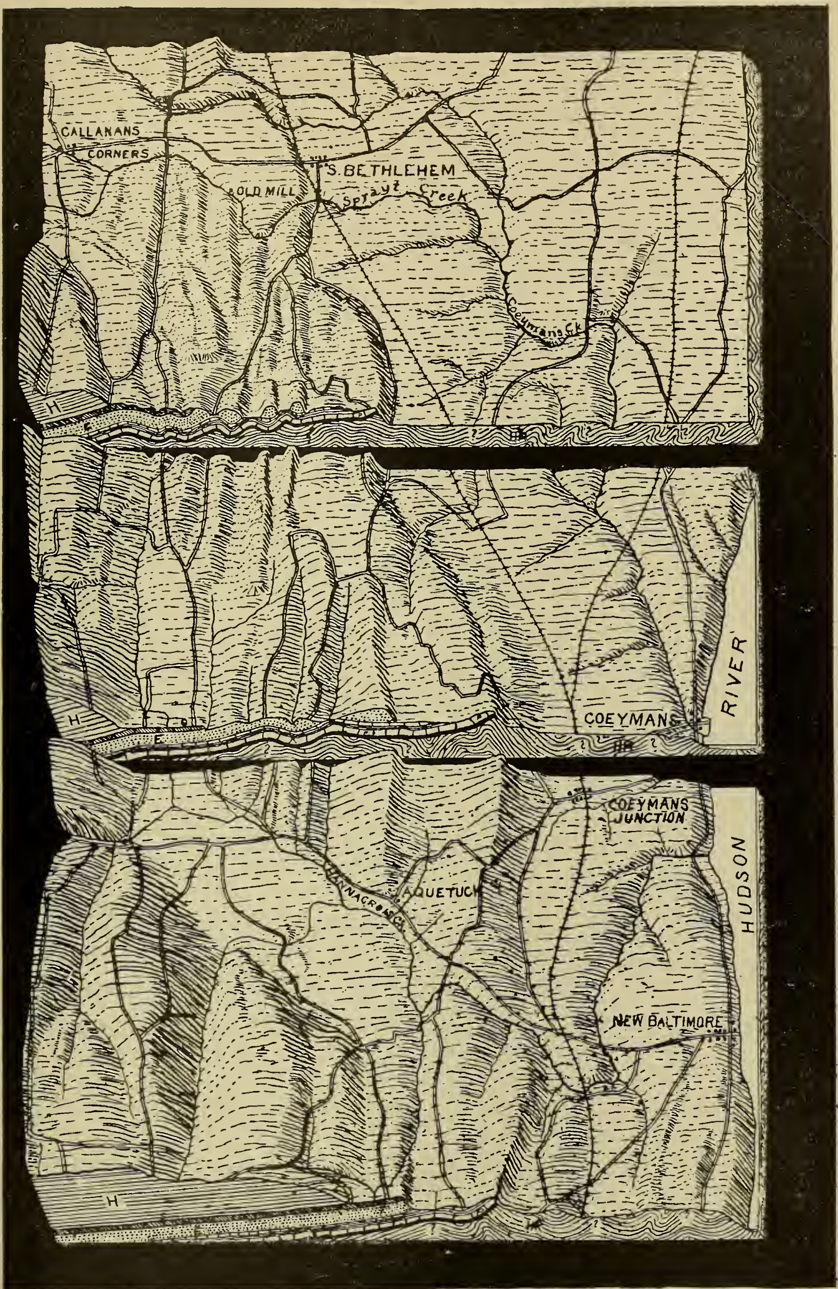
Fig. 5.—Cross section on line A–A in figure 4. From north of South Bethlehem through Copeland hill. Vertical scale, two and one-half times the horizontal scale. H., Hamilton; On., Onondaga limestone; CG., Esopus shales; O., Oriskany; S., Becraft limestone; Sl, Shaly limestone; P, Pentamerus limestone; T, Tentaculite beds and Salina waterlime; SL., Position of sea level. Looking north.

It will be seen in these figures that the undulations increase in steepness to the eastward and finally become a succession of steep parallel folds which are of true Appalachian type.

In plate 5 there is shown the structure of the flexed region in the southeastern corner of the county and for a couple of miles southward.

In this plate there should be noticed the distinct topographical characteristics of the several formations of the Helderberg and overlying formations. The steep slope or scarp of the Pentamerus bed is sharply defined except at the Hannacrois creek, where it is broken across; but it gives rise to falls of considerable amount in the creek, with a deep gorge for some distance below. The Esopus shales constitute sharp ridges and the Onondaga limestone is marked by a well-defined shelf, which expands to great width in the Hannacrois valley. The Hamilton shales rise abruptly into high, irregular hills of typical character. In the northern section on plate 5 the flexures are steep and involve the Helderberg and overlying rocks over a belt of considerable width. The steepness of the cliffs decreases southward for some distance, and near the second section there is a succession of

PLATE 5.



Stereogramic Map and Sections of the Southwestern Part of Albany County. Scale, One and Three-tenths Miles to One Inch; Vertical Scale Considerably Enlarged.

H. Hamilton shales; O. Onondaga limestone; E. Esopus slate and Oriskany sandstone; P. Pentamerus limestone underlaid by Tentaculite and water-lime beds and overlaid by Shaly and Becraft limestone; R. Hudson river formation.

gentle corrugations in a west-dipping monocline, which pitches slightly to the southward. It bears a wide area of Esopus shales, which dip beneath the Onondaga limestone to the west and south. The corrugations flatten southward and extend the Onondaga limestone over a wide area in the Hannacrois valley, also giving rise to the eastward extension of the Hamilton hills in this region.

One of the most noteworthy details of structure in southern Albany county is an overthrust of small amount, but with most interesting features. It is among the gentle flexures near the northern edge of the disturbed area in the Helderberg rocks. Its general relations are represented in the following section:

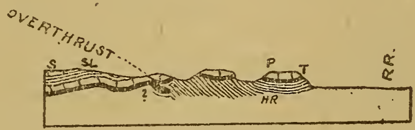


Fig. 6.

Fig. 6.—Cross-section southwest of South Bethlehem, showing relations of the overthrust. S., Becraft limestone; SL., Shaly limestone; P., Pentamerus limestone; T., Tentaculite limestone and Salina waterlime; HR., Hudson river formation. Looking north-northeast. Horizontal scale, one mile to one inch. Vertical scale exaggerated two and one-half times. This section is at 5A. on figure 4.

The characteristics of this overthrust are an "underturned" flexure in the thin-bedded underlying limestones, also involving the soft slate of the Hudson river formation, and a fault which offsets the flexure and traverses the hard, massive overlying beds of Pentamerus limestone. The overthrust is exposed only on Sprayt creek, which it crosses at an old mill about three-quarters of a mile west-southwest of the village. Its trend is north and south, but it does not appear to extend for any great distance. The principal features of the exposure at the mill are shown in plate 6, in which the enclosed wedge of slate is shown in the lower left-hand corner, the flat arch of the enclosing limestones in the middle of the view, mainly far to the right. The massive overlying series is the Pentamerus bed.

The relations at the mill and their interpretation are further illustrated in the following figures, in which the features above the broken-line portion of the sections are exposed in the bed and banks of the creek.

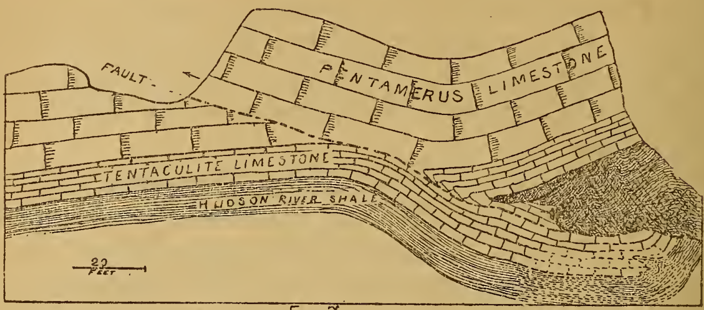


FIG. 7.— Cross-section of overthrust west of South Bethlehem, Albany county. Exposure on south bank of Sprayt creek. Looking north. (Reversed.)

I discovered these overthrusts in the autumn of 1892 and sent a brief account of their relations to the Geological Society of America.* In 1893 I again visited the locality and on careful re-examination, under much more favorable conditions, found that the features were somewhat more complicated than I had first supposed.

It is unfortunate that the exposures are not more complete, but sufficient is seen, I believe, to substantiate the interpretation given in the figure. Only the upper portion of the "underturned" fold is exposed in the limestone, but the greater part of the fault plane is visible on the south bank of the creek above the dam. The enfolded slate is seen to be excessively crumpled and its original bedding planes obliterated, but the lower limestones bend over the arch with but little fracture. There has been considerable slipping along the contact of the slate, and the portion of the limestone which is folded under is considerably broken and contorted. At several points, as shown in the figure, fragments of the limestones have been torn off and are more or less surrounded by the slate.

In the north bank of the creek, under the mill, the exposure is less extensive, but the general relations are similar to those on the south side. The principal features in this exposure are shown in the following figure.

* Published in the Bulletin, vol. 4, pp. 436-439.

PLATE 6.

OVERTHRUST ON SOUTH BANK OF SPRAYT CREEK, OPPOSITE THE OLD MILL, ONE MILE WEST OF SOUTH BETHLEHEM.

The mechanism of the overthrust is, I think, not difficult to understand, and I have represented the hypothesis of its development in the diagrams in the above figure, I, being the first stage, II, the second stage, and the present conditions the third stage.

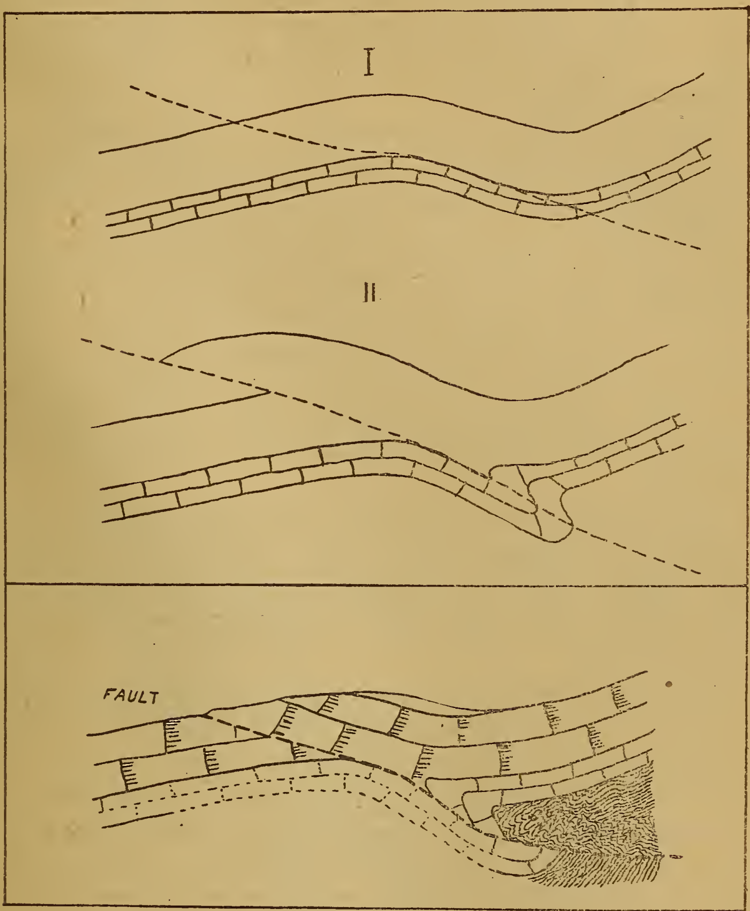


Fig. 8

FIG. 8.— Overthrust on Sprayt creek. A, cross-section on north bank. Looking north. I and II, hypothetical section to illustrate stages of development of the overthrust.

The broken line on I indicates the plane of weakness, the arrow the direction of thrust. The fault, sheared diagonally through the massive beds of Pentamerus limestone but the softer, thin-bedded, underlying limestones in moving forward with the thrust were buckled downward and backward under the soft shales, as indicated by the arrows in II before they were also fractured. The lower limestones were also considerably broken and cross-faulted, as shown in the figures. The amount of displacement of the overthrust is about 100 feet. The force was exerted from the eastward and almost horizontally in direction, unless the present low angle between fault line and axial planes is due to subsequent tilting.

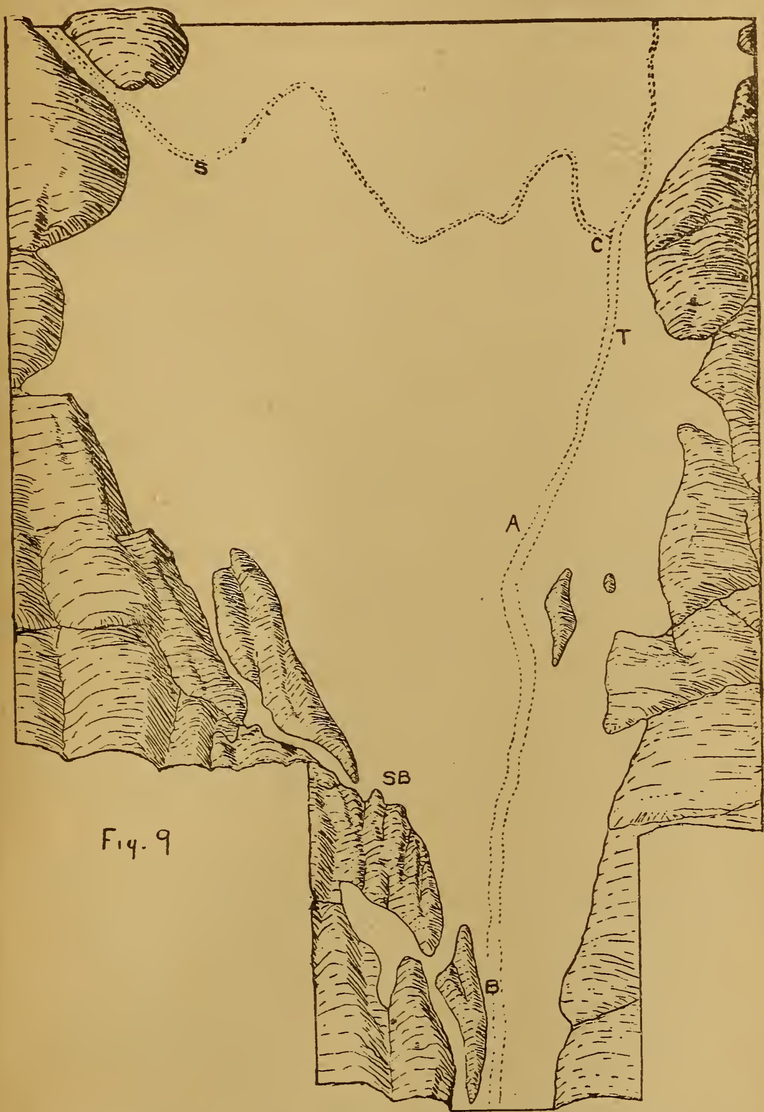
Down the creek from the overthrust the Hudson river shales are finely exposed, dipping steeply to the westward and unconformably overlaid by Helderberg beds which give rise to cliffs above. A mile below the fault the dip flattens considerably and in the center and eastern limb of this gentle synclinal of Helderberg limestones at the road metal quarry there is nearly perfect conformity between Hudson river sandstones and shales and the overlying limestones. This is only a local coincidence, however, for to the southeastward along the face of the Helderberg escarpment there is marked unconformity in the district west of Coeymans.

In this section on the plate the structure of the Hudson river rocks to the eastward is also shown, but this is intended to afford only an idea of the general features of the flexures, for owing to the heavy drift cover I was unable to ascertain the details.

Along the Hudson valley northward to Albany and beyond, the Hudson river rocks are steeply folded, probably also faulted and have an exceedingly complicated structure. Owing to the lack of distinct stratigraphy in the beds involved, to the rarity of extensive outcrops across the strike, and to the extreme contortion at all points, I was unable, in the time at my disposal, to work out the structure of the region. The contortion of the beds is exposed at many points near Albany, noticeably along the Norman's Kill near Kenwood, and southward along the West Shore railroad from "The Abbey" to Wemple. Along the Mohawk river there are many exposures of the flexed Hudson river beds. To the westward the flexures are gentle, but their steepness increases rapidly to the eastward, and at the great exposures at Cohoes falls the beds are seen to be steeply flexed and much contorted.

Pleistocene Geology.

The pleistocene deposits of Albany county consist of accumulations of glacial materials, stratified clays and sands, dune sands



ig. 9.— Stereogramic map showing the extent of the Champlain submergence in Albany and adjacent counties. Scale, seven miles to the inch. A., Albany; S., Schenectady; K., Altamont, C., Cohoes; T., Troy; S. B., South Bethlehem; B., New Baltimore. The course of the Hudson and Mohawk rivers is indicated by the dotted lines.

and alluvial deposits. There are also glacial scratches on the surface of all of the harder rocks. The glacial drift is in greater part scattered over the higher lands in masses of no great size but occurring at frequent intervals. They consist of loose deposits of gravelly sands and boulders comprising a considerable variety of rocks which occur in place to the northward. Crystalline rocks of various kinds from the Adirondacks, quartzites and sandstones, limestones and more or less local material are found. The largest deposit is on the plateau of Onondaga limestone north of Peoria and between Feurabush and New Salem. There are also a number of accumulations of considerable extent in the Oniskethau valley north of Callanan's Corners.

The stratified clays and sands occupy the great plain of the Hudson and Mohawk valleys. The clays are the basal member and the sands cap them to a greater or less thickness. The extent of these deposits is shown on the colored map. They lie on glacial drift, for the most part of no great thickness, and on the glaciated surface of the Hudson river shales and sandstones. Both the underlying drift and rocks extend to the surface in some localities as islands where the clays and sands were deposited around them. These clays and sands were deposited in the Champlain period, which followed the last glacial invasion of the region. This period was one of submergence, in which the waters of the Hudson and Mohawk rivers extended far above their present levels and overflowed all the country west to the Helderberg escarpment or the hills adjoining it to the east and north. In the preceding figure the approximate extent of this submergence is represented.

The shores to which this submergence extended are strikingly exhibited throughout, in greater part rising steeply from the plain. On the east side of the Hudson they were very irregular, and there were numerous islands and promontories. To the westward the course was relatively straight, but the waters extended up the Hannacrois and Oniskethau creeks for a considerable distance. To the northward there were open waters to Lake George and Lake Champlain over a wide area.

Near South Bethlehem and Altamont there are extensive delta deposits of sands and gravels laid down by the Oniskethau and

Boxenkill during and immediately following the Champlain deposition, for at that time the mouths of these streams were at the point now marked by delta deposits.

Some features of the clays and sands have been described by Mather, and more recently by H. Ries,* in a report on the clays of the Hudson river valley.

Mr. Ries states that in the brickyards at Coeymans Landing there are 100 feet of blue clay below, with twenty feet of yellow clay above. The latter is capped by two to three feet of loam. The deposits lie on a kame-like mass of sand and gravel at an altitude of fifteen feet above the river. This underlying series is said to exhibit some small faults in this vicinity. The sand is of grayish-black color, consisting of grains of quartz and shale, mostly the latter. There are, however, also grains of garnet, epidote and feldspar, and scattered through it are pebbles of quartz, etc., most of them not over an inch in diameter. Sixty feet of this sand was penetrated in a well near the brickyards.

Respectfully yours,

N. H. DARTON.

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*The Hudson river brick clays. Tenth report of State Geologist (of New York), for 1890, pp. 124-155.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

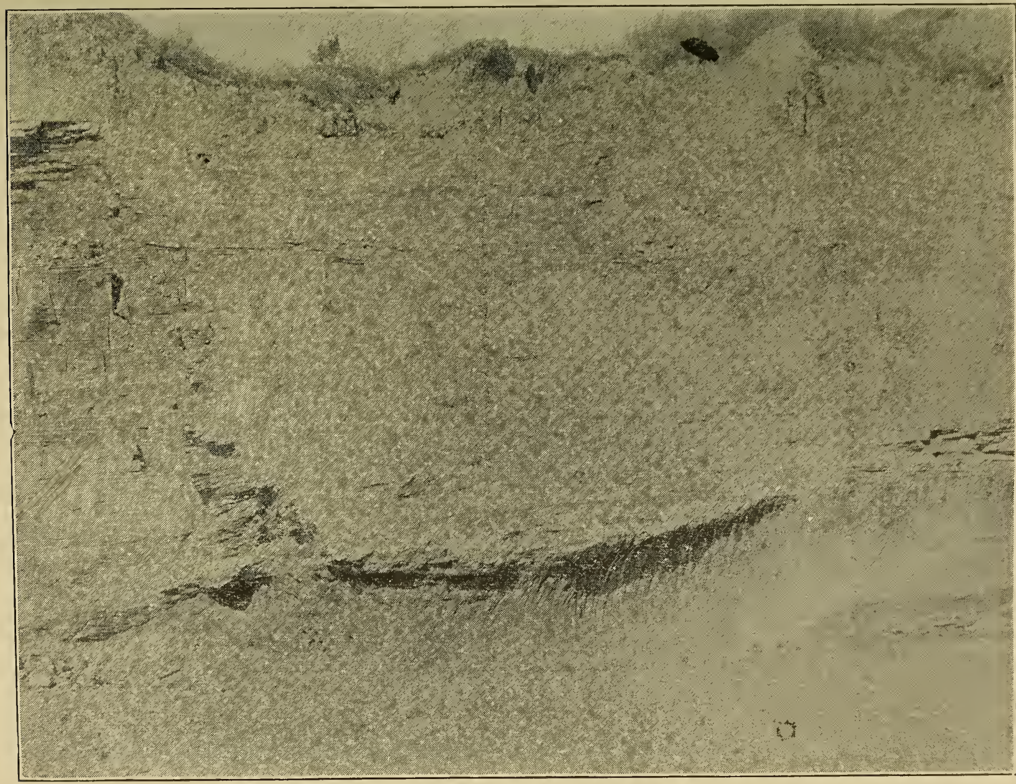
(GEOLOGICAL MAP.)

The Economic Geology of Albany County.

JAMES HALL, State Geologist. FRANK L. NASON, Assistant.

1893.

PLATE I.



J. C. Moore's Sand Bank, Albany. Showing Stratified Blue Clays Lying Unconformably on Sands and Gravels.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

The Economic Geology of Albany County.

By Frank L. Nason.

James Hall, *State Geologist:*

Sir.—There are no metal mines in Albany county. The sources of wealth contained in the geological formations are confined to quarries, clay and sand banks, and to the water power developed by such streams as the Mohawk, Normanskill and several minor streams. Geologically, each of the products mentioned may be referred to a definite age.

I. Limestones and shales, confined to the Silurian, next to the oldest palæozoic formation.

II. Flagstones of the Hamilton group of rocks; Devonian in age.

III. Gravels, clays, molding sands; confined to the Quaternary, the most recent geological age.

The sources of geological wealth may then be divided as in the following table:

Geological age.	Material.	Uses.
Silurian	Limestone	Building and dimension stone, bridge, ashlar, crushed stone or road metal, lime, and Portland cement.
Devonian	Cauda-galli grit	Road material (not road metal or crushed stone).
Silurian	Hydraulic limestones	Hydraulic cement.
Devonian (Hamilton group).	Flagstones and sandstones	Flagging for sidewalks, door and window sills, curbs, posts, water tables, etc.
Quaternary	Building or quicksands	Mortar and cement, brick and tile, asphalt pavements and sidewalks, sand and gravel walks and drives.
"	Molding sands	Molding sand for light, medium and heavy castings, brass, iron, bronze or steel.
"	Clay	Bricks, tiles, pottery, glazing, modeling, etc.
No particular geological age	Water	Water power, navigation, irrigation, medicinal springs.

THE GRAVELS, SANDS AND CLAYS.

The gravels, sands and clays of Albany county belong, as has already been stated, to the Quaternary age. They are a part of a more or less connected whole, extending from the Highlands of the Hudson to the St. Lawrence river.

Their boundary lines in Albany county may thus be roughly outlined. Beginning at Coeymans Landing on the Hudson they are bounded on the southwest by the Helderberg mountains, on the north by the Mohawk, and on the east by the Hudson. The deposits do not stop at the county lines, but extend through the northwest part of the county reaching to the Mohawk river in Schenectady county.

Inclosed within this triangular area are numerous high rocky points which were probably islands during the period of time in which the laminated clays and molding sands were deposited.

Along the southwestern flank of the Quaternary shore line the coarse delta sands, cross-bedded and of irregular texture, lie against the rocks of the Helderberg mountain series, while along the Mohawk and Hudson rivers the same deposits lie upon the uneven surface of the Hudson river group of sandstones and slates, a deposit of glacial clay with striated pebbles usually intervening. The relation of these deposits to the rocks is clearly shown at many points. At Coeymans Landing the Coeymans creek falls over a precipice of these rocks; at Van Wie's Point they reach to a considerable height above the river level; at South Albany, at Kenwood and in the city proper the slates appear at varying levels. At North Albany a cutting in the New York Central railroad shows the crushed and polished slates not fifty feet above the river level. Westward is a depression, partly filled with laminated clay, but near the railroad shops at West Albany the slates again appear. Thence following a line nearly due north, which swings out and in toward the Hudson river, through Menands and West Troy, the slates reach the Mohawk at Cohoes, over 200 feet above the level of the Hudson. From the foot of the falls in the Mohawk, at Cohoes, the river flows over slate rocks, while in its bed are numerous small rocky islets with precipitous sides and of varying altitudes, none over seventy-five feet in height, which remain to point out conclusively the work of the river in the past.

PLATE 2.

VAN RENSSELAER'S SAND AND GRAVEL BANK, NORTH ALBANY, N. Y.

To the west and southwest of this ridge the eye reaches with almost unbroken sweep across a terrace which extends to the line of the Helderbergs. This terrace is not now easily distinguishable, but there is little doubt that when the receding waters left it it was nearly level. With the rising of the land and the consequent recession of the estuary waters a new era began. The Hudson began cutting its present channel in the estuary sediments. The meteoric waters falling on the terrace began to cut a way to the river and gradually the courses of the larger streams were determined and these with their feeders began the work of destroying what the estuary waters had built up. The result is what is seen to-day. The once level terrace is cut up into irregular ridges and hummocks, and it is only by the exercise of the imagination that we can conceive of the filling up of these miniature valleys and gorges to their former level, marked only by the broader-topped and higher ridges which now remain.

To return now, for a moment, to the barrier of Hudson river slates parallel to the Hudson river up to the Mohawk at Cohoes, we may say with a strong degree of probability that this barrier has determined to a marked degree the course of the principal drainage of the country west of Albany. From this fact, and from the facts which have before been noted with regard to the height of these rocks above the level of the river, we may safely infer that the delta deposits of coarse sands and gravels, the estuary deposits of laminated clays and molding sands rest on the unevenly eroded surface of these slates. Later on some useful hints may be drawn from these facts. At present we shall consider the nature of these deposits and their relations to each other.

The cross-bedded sands underlie the stratified clays Generally they are found resting on the Hudson river group of rocks. In places, however, the glaciated rocks appear to have been swept bare of the sands, thus allowing the clay to rest directly on the rocks. As a rule, however, the sands will be found underlying the stratified clays; the clays lying unconformably on them. Plates I and II show this unconformity.

In regard to the depth to which these sands extend nothing certain is known. On Jay street, in Albany city, the Amsdell

Brothers Brewing Company bored a well 1040 feet in depth. The first 200 feet of the well went through sand and clay, and then the solid rock was struck, probably Hudson river slate. Near Morton street, in Albany, the Hudson river slates appear on the surface. It is, therefore, probable that the sands were deposited on the rocky surface which had already been irregularly and often deeply eroded. At Van Rensselaer's bank, North Albany, these sands are found 200 feet above the level of the Hudson. Plate III gives a typical illustration of the appearance of the sands.

The grains and pebbles making up the bulk of the deposits are, in the order of abundance, slates, quartzite, limestone, gneiss, grains of limpid quartz, garnet and magnetite. The larger pebbles of gneiss and quartzite occasionally weigh upwards of 100 pounds, though these sizes are rare. Large pebbles of quartzite are also often found. Glaciated pebbles and boulders are rarely observed. The majority, even of the larger sizes, are smooth and water worn. The finest material is the limpid quartz and garnet. The coarse pebble beds do not occur in uniform strata, but are irregularly distributed through the lenses of coarser sand and gravel. The coarse sand layers, and the layers of finer sands, do not occur in regular strata, but in great lenses. These lenticular masses, thickening and thinning, give the appearance of cross-bedding. The origin of the detritus forming the gravel deposits is glacial, but the glaciers derived the material from the beds of slate, quartzite, gneiss and limestone which lie to the north and east. That the material is not immediately glacial is proved by the fact that they are stratified, in distinction from till or boulder clay, and also that the pebbles are well rounded, showing water action on a beach.

The deposits of sands of the above nature are found under the clay banks, as is shown at Coeymans, Albany and West Troy, sometimes rising above the clays, as at North Albany; occasionally in gravel hills through the valley between Albany and the Helderberg mountains, and especially along the foot of the Helderbergs. The economic uses to which these sands are put are many. They are quicksands, and can never be used for molding unless prepared artificially by mixing with clay and molasses, which is only done where molding sands are not found. The two prin-

PLATE 3.

McCarty's Sand-bank, Albany, N. Y. Showing Stratified Blue Clays Lying Unconformably on Sands and Gravels. Faulted Clay Strata

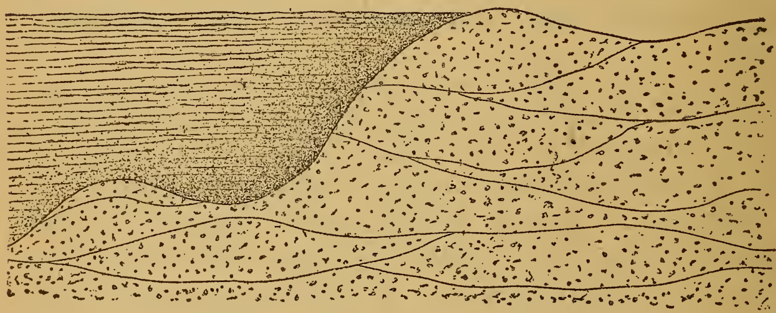
cipal uses of this sand are for tempering brick clays and for building. After being screened for mortar, the coarser sand is used in great quantities for gravel walks, both loose and as asphalt, and for mixing in concrete. Some of the coarser material is used for graveling public roads, and the coarsest is employed for paving gutters and water-ways and streets. For all of the above purposes there is an abundance of this material which is very accessible.

The brick clays lying above these cross-bedded sands are of two kinds, in respect to color. The first, in course from bottom upwards, are the laminated blue clays. The next above these and separated by a very distinct line are the yellow clays. When the clay beds are shallow, from ten to fifteen feet thick, often only the yellow clays, well stratified or rather laminated, are found.

So far as the writer knows, no analyses have been made which show whether or not the difference in color is due to chemical composition. The ordinary analysis is usually satisfied with the amounts of iron present without determining its state of oxidation. It is a fact that all along the Hudson river and in New Jersey these two clays are found, and under the same conditions as to relative position. Considering these positions and also the fact that the thinner beds show no blue clay, or only in patches, it would seem that the difference in color is due to the oxidation of the iron. It is probable that the blue clay owes its peculiar tint to iron in the protoxide state, while the yellow clays owe their color to more or less of the irons existing as a peroxide. The writer is told by brickmakers that the blue clays alone do not give as bright a red as the yellow, and that in order to get the best results the two are mixed. This could be explained by saying, which is probably true, that nearly, if not quite, all of the blue clay contains its iron in the protoxide state, and that in the process of burning, the iron is not thoroughly oxidized; while in the yellow clays this process has already taken place to a considerable degree and the burning simply reduces the iron to an anhydrous peroxide which is red.

As the clays rest either on the rock or on uneven cross-bedded sands, it is, therefore, probable that the clays are everywhere younger than the sands and gravel. This would seem to indicate that the more or less torrential conditions under which the gravel beds were deposited had given way to a slower subsidence. During this subsidence deep gorges had been cut in the gravel beds, in many places quite down to the underlying rock beds. Then, during the quiet, and probably deeper waters, the clays were deposited, quite filling these depressions. That the clays were deposited during a slow subsidence is beautifully shown by phenomena which are visible in many clay banks now being worked. Fig. 1 is a view of a clay bank just south of the Knickerbocker icehouse at Coeymans. Here a large bank of

Fig. 1



Section of Clay Bank
Showing fine sandy layers gradually passing into fat clay.

sand divides to the surface of the clay beds lying on either side of it. The sand bank itself is of coarse cross-bedded gravels. Just where the clay would naturally come in contact with the sand or gravel the entire mass is made up of fine argillaceous sandy layers as distinctly laminated as on the clays. Going south from this point the argillaceous sand gives place gradually to layers of clay with fine sand and within fifty to one hundred feet fat clays are found exclusively. In other words the fat clay gradually changes to fine sand as the contact with the gravel beds is approached. These phenomena may be observed in many of the clay banks of South Albany. From the above facts it seems reasonable to infer that during the disposition of the clays the gently lapping waters removed the finer material from the coarser gravel and redeposited it in the finely laminated argillaceous layers.

In studying these beds, even casually, another set of phenomena becomes very apparent and is at first somewhat puzzling to explain. In the clay banks of Slinger and Niles, at Coeymans, a layer of blue clay about one foot in thickness and one hundred feet long is crumpled and gnarled, appearing as though its laminæ had been disturbed by some dragging or shoving weight, while above and below the layers are exactly parallel and wholly undisturbed. The layer was so uniform in color that the structure would not permit of being successfully photographed, so a drawing, giving an idea of structure, was made, which is not, however, an exact reproduction. (See Fig. 2.) Such

Fig 2

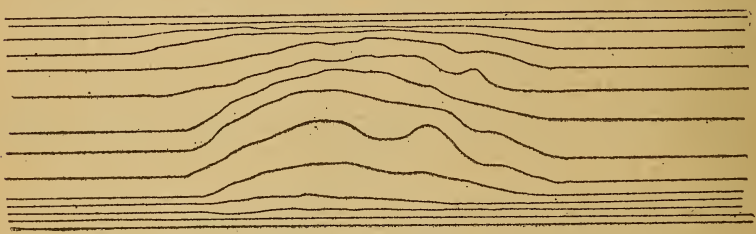
Crumpled strata between two parallel strata.

structure has been and, in the autumn of 1893, is still to be observed in the clay banks of both Ulster and Albany counties. This phenomenon may be explained in the following way. Bearing in mind the fact that the clay banks are underlaid by sand, the water circulating through these sands gradually undermines the clay bank and tilts it to such an angle that one part of a bed would slide over the other, only leaving visible marks along the particular stratum disturbed and in the form of crumplings. Many of the clays lie at an angle to the horizon and only a slight tilt would suffice to give rise to a slip. That the explanation is at least plausible is brought out by the following facts.

At several clay banks small springs emerge from beneath. At nearly all of these springs the clay is bent downward and crumpled, much as is shown in fig. 5. The disturbance extends only a few feet horizontally and vertically, and beyond these limits the laminæ are undisturbed. This deformation is here evidently due to a washing out of the mobile quicksand leaving the clay unsupported, thus allowing it to flow as a viscous body until the opening is filled.

Still another phenomenon is shown in fig. 3, where a swelling and crumpling takes place in the body of the bank and of very

Fig. 3.

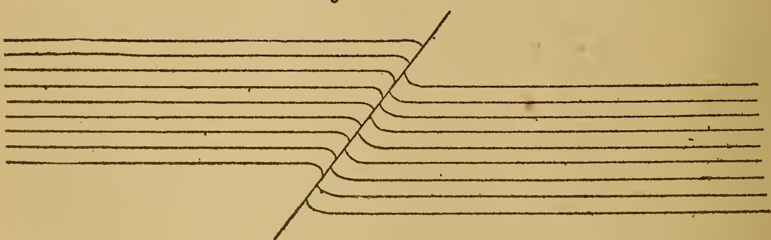


Crumpling of laminae between parallel strata

limited extent, say from four to six feet in length and from one to three feet in height. This may be but the fading out of a sliding motion in a plane shown in fig. 2, or where an incipient fold has taken place instead of a disturbance in a sliding plane.

The above may be but the beginning of a slight faulting which is shown in fig. 4 and which is of frequent occurrence.

Fig. 4.



Slightly faulted clay strata

All of these phenomena may be explained by the undermining of the clay, by the removal of the underlying sand by water, and the consequent tilting of the strata if the removal of sand be sufficient or the production of small sags, shown in fig. 5, if the sand removed be less in quantity.

Fig 5

Sand washed from under clay bank causing a flow of the clay.

From what has been said of the relation of the clays to the gravel beds as well as the limitations in extent toward the Helderberg mountains, it may be inferred that clays will be found throughout this valley. This is no doubt true. Stratified blue clay underlying yellow clay may be seen in the public road near Feura Bush, a station on the West Shore railroad. In many places west of Albany wells ten or fifteen feet deep or less are dug in the sand and have an abundant supply of water. This could only happen when the sand was underlaid either by clay or some other impervious stratum. In these cases there is direct evidence that this stratum is clay. There are deep gullies with rather steep slopes running through the fields. The sides and bottoms of these slopes are usually wet and ploughing shows a clayey soil, which is probably a wash from the clay strata. Sometimes traces of lamination are visible. In places there is no doubt but the clay will be found to be "pockety," inclosed in small hollows in the rock or san

In the city of Albany are extensive areas of clay of great thickness. From North Albany the New York Central railroad tracks are laid on clay for a distance of 1300 feet. South of the tracks are other heavy banks as yet untouched. On Ten Broeck street clay is worked to a thickness of twenty-five or thirty feet. The clay is of unknown depth. The banks are worked down to city grade and then the lots are built upon. On Orange street clay is dug, but a depth of thirty to forty feet is left, which is below city grade.

The uses to which the clays of Albany are put are not varied. The most common product is the ordinary building brick. Drain tiles are made by only two companies and pressed front bricks by but one company. There is no known reason why the finest class of bricks should not be made with the material at hand, except that there is a ready market for the cheaper class of bricks and they require much less care in molding and burning. There is one clay product, however, which seems to be peculiar to Albany county, the "slip clay" for glazing pottery. Large quantities of this are dug and shipped in barrels to all parts of the United States and to Canada. "Large quantities" must be taken in a moderate sense, for as it is only used in making a glaze a small quantity will suffice for a large pottery. It is only when the material is supplied to a large number of works that the total amount is considerable. How great is this quantity cannot be ascertained, as the dealers are very reticent in regard to their product.

Nothing could be learned of its mode of occurrence beyond the fact that it is a stratum four to five feet in thickness. Salt and soda compounds give a ready glaze to pottery, but it is apt to check and crack, thus making the vessel more or less pervious to contained fluids. The slip clay gives a strong glaze at a low temperature, and it is said rarely cracks or checks. The value of this clay is attested by the fact that it is used by many potteries, not only in the United States but it has even been shipped to Germany and France.

Molding Sands.

There are shipped from Albany county from sixty to eighty thousand tons of molding sand each year. According to Mr. T. S. Caldwell, of Selkirk, this sand is found from the Adirondack mountains to New Jersey. It occurs in the largest bodies and of superior quality and strength in Albany county.

The peculiar qualities which go to make up a molding sand consist of elasticity, strength, and of a certain degree of fineness. It must be plastic in order to be molded around the pattern; it must have sufficient strength to stand when unsupported by the pattern, and to resist the impact of the molten metal when poured into the mold. Too much clay and iron present in the sand will cause the mold to shrink and crack under the intense heat, too little will cause it to dry and crumble, if not to entirely collapse. The purpose for which the sand is used depends upon its fineness. For very heavy castings very heavy coarse sand must be employed; but for the finer grades and lighter castings, such as brass, stove plates, and light steel, where smooth surfaces and sharp edges and lines are to be produced, only the finest grades can be employed. In many places where this peculiar sand is not found and where freights are too expensive, an inferior grade is made by mixing quicksand with clay, flour and treacle. Though no chemical analyses of the molding sands were made, the physical differences between quicksands and molding sands are easily discerned. Quicksands are composed principally of grains of quartz, with magnetite, garnet, feldspar, slate, etc. Such sands when dry have no stability or plasticity, but when mixed with water have a distinct flow, hence the name quicksand. If, either naturally or artificially, these same sands, when of uniform size, be mixed thoroughly with a certain amount of fine clay they become plastic, will stand perpendicularly when moist or even dry, or will overhang. The sands then are known as molding sand. It might at first thought seem a very easy matter to make an artificial molding sand of equal value to the natural. In fact, however, this is quite difficult, if not impossible. If the grains of sand in the natural material be closely examined with a pocket lens it will be seen that each is coated with a film of clay. It thus follows that if any two grains be brought into contact when moistened they will adhere. If now these grains be heated to redness their plasticity or capacity for adherence has been destroyed, and they become practically quicksands. That is, the clay and iron have been dehydrated, or all the water chemically combined has been driven off. Every molder or foundryman knows that when the best sand has been used for casting after awhile it becomes lifeless, and it is then said to be "burned."

The molding sand is found, not in heavy banks, but beds of varying thickness. These beds are underlaid by coarser well-stratified sand beds more nearly allied to quicksands. Then come the molding sands, varying from six inches to three or five feet in thickness. Over this bed lies about the same thickness of soil. Originally this region was nearly a plain, but with the emergence of the land from the water the rains have gathered into brooks and larger streams. In consequence, instead of a uniform plain the fields are made up of minature plateaus, more or less broad-topped. The summits of these carry the sand, while the drainage streams, more or less intermittent, have cut down to and into the underlying beds of clay.

In gathering the sand for market a section of land one or two rods in width is stripped of its overlying soil and down to the sand. The sand is then dug up and carted away from this strip. After the sand is moved from the first strip a second belt is cleared of soil and dumped on the first and so on until the whole field has been stripped of its sand. After stripping the entire field the soil is replaced and leveled down and is then just as good for agricultural purposes as before. Some farmers even claim that the land is improved thereby. The farmers themselves rarely do the stripping since it takes one well acquainted with the requirements of the trade to make the nice distinctions between the grades of sand fitted for the different castings. Consequently a dealer buys the sand on a farm from the owner and pays by the ton. Mr. F. S. Caldwell estimates that each six inches of sand will yield one thousand tons per acre. The price paid to the farmer varies from five cents to twenty-five cents per ton, according to accessibility to the river. At present the sand is not hauled over six miles.

The sand is delivered either near Albany or at some other shipping point near the river and stacked in huge piles. From these the material is hauled to the river and shipped in boats as required.

In regard to extent or future supplies it will suffice to say that only the farms which lie from five to seven miles from the Hudson river have been touched. The whole valley from the Hudson to near the West Shore railroad tracks, about the eastern foot of the Helderberg mountains, is largely covered and as the near supply is exhausted the more distant sources will be drawn upon.

Flagstones.

The flagstones quarried in Albany county come wholly from the Hamilton group of rocks. In the Helderbergs they are found nearly two thousand feet above sea level. This range runs in a northwest-southeast direction across the county. The localities where the quarries are most numerous are at Reidsville, South Berne, Dormansville and Alcove. The quarries are not centered in these particular localities, but are from five to seven miles distant from the immediate vicinity.

The method of working these quarries is explained in the description of the flagstone industry of Ulster county. In the Helderberg region, however, there are more farmers who work their quarries intermittently than in Ulster county. The reason is probably twofold. In the first place the stone is not nearly so convenient to shipping points. A great deal of the output is hauled to Coeymans landing, twenty-four miles distant, and to Albany, nearly sixteen miles. These distances are reckoned from Reidsville. Again the stone here does not appear to be so heavy bedded, and thus only the lighter flags are produced. The best idea of the way in which the quarries are worked may be gained from a particular description of the quarries of Messrs. H. and G. Steward, of South Berne. The quarry is located on an easily sloping hillside facing the west. The working face is about 300 feet long. The material which has to be stripped off consists of shaly or slaty material which is worthless. This worthless material is about eight feet thick. The men owning the quarries do not work them; they rent to any one who wishes to quarry stone. The renters pay five cents per square foot of surface measure. At the Steward quarry a face about 300 feet long and 50 feet wide was about worked out in October, 1893. The rental paid to Mr. Steward would then be made up in the following way: 300×50 feet = 15,000 square feet. Paid for at five cents per square foot equals $15,000 \times .05$ feet = $750 amount paid for the above block.

This same block of stone would average about five feet in thickness. Each foot thick of stone will yield on an average three flags four inches thick. The number of square feet flag measure which this block of stone ought to yield the "renters" will be as follows: Length, 300 feet; width, 50 feet; thickness, 5 feet; number of flags per foot 3; equals $300 \times 50 \times 5 \times 3 = 225,000$ square feet flagstone measure. The flags are then sold on the ground to buyers, who haul them either to Voorheesville on the Delaware and Hudson, to Albany or to Coeymans Landing on the Hudson river.

In the above estimate of production no allowance has been made for broken flags, thin layers which are worthless or loss by trimming. This is at times very considerable. The joint planes in the quarry determine to a certain extent the size of the stone. These joints, instead of being at right angles, are usually acute angled, the stones thus coming out in the form of parallelograms instead of squares. Four feet or more are thus often lost from each stone. Checks and flows often render a flag worthless, and it is passed to the waste heap. Probably at least 75,000 feet would have to be taken from the 225,000 feet, estimated contents of the stripped block.

Nearly all of the larger quarries are worked on this system. Some of the large handlers of flagstone own one or two quarries only. By far the larger number of the quarries are worked intermittently.

While it is true that the quarries of Albany county can not produce stone equal in dimension to those of Ulster county, the material that is produced is of a very superior quality. The extension of the output is hampered by lack of shipping facilities. The nearest point of shipment by rail is sixteen miles distant, while tide water is twenty-four miles away. For several months in the year the roads are practically impassable to heavy loads. The heavy rise from Clarksville to Reidsville and South Berne soon uses up the very best teams. It is hard work hauling the heavy loads down the long steep hill, and the work is not much less when it comes to hauling the necessarily heavy wagons back again. This lack of transportation is the sole obstacle in the way of a wide development of the flagstone business in the county. There is an abundance of the material, of excellent quality, and the labor of stripping the beds of workable stone is really less than in many other localities.

PLATE 4.

CALLANAN'S QUARRY AND CRUSHING MILL, SOUTH BETHLEHEM, N. Y.

LIMESTONE FOR BUILDING.

The Lower Helderberg and Corniferous limestones are well-developed in the county, but very little stone is got out for building.

Near South Bethlehem, on the farm of Mr. W. Mosher, some limestone was quarried for high abutments during the construction of the West Shore railroad. Some rough building stone is occasionally quarried, but only intermittently.

The quarries of Mr. P. Callanan, of South Bethlehem, adjoin Mr. Mosher's farm. Here there is a large stone crushing plant and a large amount of stone is quarried for crushing. A spur from the West Shore railroad comes into the quarry. These facilities give Mr. Callanan an opportunity to quarry, to good advantage, stone of almost any size. The principal use to which the stone is put is for bridge abutments, dimension and foundation work. Even with these facilities for quarrying and handling there is but little stone shipped.

CEMENT ROCK.

In the quarries above referred to the hydraulic limestone or water lime group of rocks occurs. The beds are thin, not exceeding nine feet in thickness, and no persistent attempt has been made to manufacture natural cement.

LIME.

In the vicinity of Clarksville and Knowersville, now called Altamont, several limekilns have been built for burning lime. They have never done more than a local business, though there is no reason why lime of good quality should not be made.

ROAD METAL.

The only road metal plant is owned and operated by Mr. P. Callanan, of South Bethlehem. This is a very extensive and well equipped plant. The accompanying plates give an excellent view of the quarry and mill. Since the views were taken the mill has been doubled in size and capacity. The views were obtained through the courtesy of Mr. Callanan. Its location is most advantageous for cheap quarrying, crushing and loading on the cars. The quarry is operated on the steep eastern face of one of the lower foot hills of the Helderberg mountains. A little above the level of the floor of the quarry the mill is built against a precipitous rocky ledge. The crushers are about thirty feet above the spur from the railroad. The limestone is blasted from the face of the quarry, broken, loaded into trains and hauled by winding engines to the crushers. The material is crushed, screened and sorted according to size and is then distributed to stock bins, which, by means of chutes, communicate directly with the cars. After the stone is loaded into trains the remainder of the work, even loading into cars, is done by machinery.

The working face of the quarry is 500 feet long and ninety feet high. The length of the quarry face could be made greater if necessary. The mill turns out from 25,000 to 30,000 cubic yards per year. Fifty men are employed nine months out of twelve.

The material is used almost exclusively for macadam and concrete walls. It is shipped east and south. Some of the fine material, reduced to a powder and mixed with asphalt, is used for making asphalt pavements and sidewalks. The limestone from which the metal is made is geologically known as the Tentaculite limestone, and is excellent for the purpose for which it is quarried. It is fine grained, compact and very tough. The beds are very heavy, and there does not seem to be the slightest tendency to lamination, consequently the crushed stone never splits up finer when in use. Analyses made by Prof. Mason, of the Rensselaer Polytechnic Institute, Troy, N. Y., show the stone to be ninety-six per cent carbonate of lime.

Higher up in the Helderberg series are found the Cauda-galli grits. This material has to some extent been used in making roads. There is no doubt that the roads of the county would be improved by the use of this material. The initial cost of macadamizing is almost as great as with crushed stone, and the benefit to the roads would be but transient.

What is required of a good road metal is a stone that is not easily crushed, that will not crack or crumble in any weather, and one that is soft enough to pack tightly. The Cauda-galli grits fulfill most of these conditions. Like many sandstones they may go to pieces under the action of the weather, and may crush under ordinary road traffic, or under a steam roller, such as used in

PLATE 5.

Callanan's Quarry, South Bethlehem. Showing the Amount of Rock Thrown Down by a Single Blast.

ordinary road making, but the alumina which they contain would tend, to some degree, to cement them, and the grains of sand would render them less liable to attacks by rain or melting snow. The consequence is that rain storms would not wash out the road as readily as the ordinary sand or dirt road.

Under certain circumstances, therefore, these grits may be considered as a cheap and desirable road material; but with an abundance of limestone the latter would make an excellent substitute even though the initial cost be a little greater.

Natural Gas.

There has been more or less general belief that in Albany county conditions were favorable for the production of natural gas. There has, however, been no great excitement on the subject.

In the summer of 1886, June twenty-sixth, practical exploration of the rocks began with the object settling the question as to whether they contained gas. Drilling was begun about one-fourth of a mile from Knowersville, now Altamont, a station on the Delaware and Hudson railroad. The elevation of the mouth of the well is 510 feet above tide, and 595 feet below the base of the Lower Helderberg limestone.

The well was drilled to a depth of 3,000 feet. The drill for the first 2,500 feet is reported to have passed through gray shales, gray and black slates, alternating, quite calcareous in places and occasional thin beds of sandstone. At a depth of 497 feet a "gas vein" was struck which in 1888 produced gas at a confined pressure of forty pounds per inch. This was the only indication of gas in the well. On account of the difficulty of getting water to carry on the drilling a water well was drilled to a depth of 325 feet, within three feet of the deeper well. No water was found in the second well, but at a depth of 200 feet a pocket of gas was struck. This gas burned to a height of three or four feet for twenty-four hours when it became exhausted.

The geological structure of the rocks in which the Knowersville gas was obtained is such as to make it hardly possible for them to contain gas in larger quantities than was found in the Knowersville well. The question as to whether they actually do contain gas was tested in another locality. The pressure of gas in the Knowersville well from a sandstone stratum only six inches in thickness which continued for eighteen months, seemed to indicate that if the sandstone stratum was thicker it would contain a proportionately larger supply of gas. In order to determine whether or not this gas sand was thicker elsewhere a second well was drilled. This was located on the Finch farm in Knox township four and one-half miles a little west of north from the Knowersville well.

The elevation of the top of the Knox well, 1,155 feet above tide or 645 feet above the mouth of the first well. The well was begun in the Hudson river group of rocks. The geological horizon of the gas sand in the Knowersville well was passed through in the Knox well between 1,000 and 1,050 feet, but no gas was found. Drilling was stopped in this well at a depth of 2,200 feet or 1,200 feet above the top of the Trenton limestone.*

Water Power.

The principal water power in the county is supplied by the Mohawk river at Cohoes. To this power alone the flourishing city owes its existence. The Mohawk is about 175 miles long and drains a territory which is on an average 20 miles wide. The total drainage area is thus about 3,500 square miles. Before reaching Cohoes the river has received the last of its larger tributaries, so that at this point the stream has reached its maximum power.

At the city the river falls over an abrupt precipice, seventy feet high, of Hudson river slate. From this point to the Hudson it runs a wide and rapid stream, part of the distance between rocky walls and all of the way over a jagged bed of slate.

The rights of this power are owned entirely by the "Cohoes Company." In order to divert the water of the river a great dam has been constructed about one mile above the city. This dam is 1,443 feet long. The gate house is 218 feet in length, in addition to the above, making a total length of 1,661 feet. The total fall of the water from top of the dam to the point of discharge below the falls is 125 feet.

* The notes on the gas wells drilled in Albany county are from "Petroleum and Natural Gas in New York State," by Chas. A. Ashburner, M. S., C. E. A paper read before the American Institute of Mining Engineers, Duluth, meeting July, 1887, and revised in June, 1888.

PLATE 6.

FALLS OF THE MOHAWK, COHOES, N. Y.

The method of using the power here is about the same as used by all great water power sites. That is, the water is lead to the turbines of one mill, the spent water flowing along a canal to the next mill, the turbine of which is about ten feet below the level of the first, and so on. In Cohoes the water is used at five levels with a fall at each level of about twenty feet.

The minimum total horse power developed is 10,000. This is estimated for the dryest season.

The power is sufficient for the mills throughout the entire year. No supplementary steam power is needed. There is yet power to spare.

The bare statement that the Mohawk supplies 10,000 horse power gives to the uniniated but a faint idea of its value. To put the same fact in a different form, the city of Cohoes has about 25,000 inhabitants. Of this total population sixty per cent, or 15,000, are employed in the knitting, spinning and iron mills, and in the electric light and power plants. One mill alone, "The Harmony," when working on full time employs 6,000 hands.

The accompanying plates show both the falls and the gate house. The plate of the gate house was reproduced from a very large photograph in the office of the Cohoes Company at Cohoes.

The plate of the falls shows the dam in the distant background. The view was taken at low water, since at high water the clouds of mist and spray completely blot out the surroundings.

At Kenwood, two miles south of Albany, the Kenwood grist mills and the Kenwood felt mills* are supplied with power by about thirty-eight feet of fall in the Normanskill creek. The total horse power developed is about 150. At the felt mills steam is used to supplement the water power.

At Alcove, Normansville, South Berne, Coeymans Hollow, Rensselaerville, and other places in the county, there are small grist and saw mills for local work only.

Respectfully yours,

F. L. NASON.

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* Burned since the preparation of this report.

BRICK AND TILE MANUFACTURERS AND PRODUCT, ALBANY COUNTY, N. Y.

MANUFACTURERS.	Location.	Men employed.	Common bricks, per annum.	Pressed front bricks, per num.	Drain tiles, per annum.	Markets.	Fuel.
Jackson Brothers	South Albany	30	....	500,000	2,000,000	Eastern and Middle States	Wood.
W. M. Bender & Co	South Albany	....	....	....	....	....	Soft coal.
A. Poutre	Albany	25	1,750,000	....	....	Local	Wood.
A. Hunter	Albany	24	2,000,000	....	....	Local	Wood.
Albany Brick Company	South Albany	40	4,000,000	....	....	Local	Wood.
* J. C. Moore	South Albany	54	5,750,000	....	....	Local	Wood.
Smith Brick Company	South Albany	20	1,700,000	....	....	Local	Wood.
* Babcock's Yard, see J. C. Moore.							
J. A. Brown	Coeymans	....	4,500,000	....	....	Local	Wood.
L. K. Brown	Coeymans	38	3,500,000	....	....	New York	Wood.
Slinger & Niles	Coeymans	38	3,500,000	....	....	New York	Wood.
† Sutton & Sudderly	Coeymans	150	12,000,000	....	....	New York	Wood and coal.
Corwin & McCullough	Coeymans	40	3,500,000	....	....	New York	Wood.
E. S. Wiswall	West Troy	20	2,000,000	....	....	West Troy	Wood.
‡ H. D. Tupper	West Troy	25	750,000	....	....	West Troy	Wood.

PRODUCERS OF SLIP CLAY.

§ Jackson Brothers	Albany	....	....	....	....	All parts of the world	
§ M. V. B. Waggonner	Albany	....	....	....	....	All parts of the world	
§ Albany Slip Clay Company	Albany	....	....	....	....	All parts of the world	

* Moore and Babcock work their yards together. Have three yards.

† Sutton & Sudderly own the bank and yards of the three preceding companies. They work on the same bank. The capacity of the three yards is 32,000,000 per annum.

‡ This yard has been running out a part of the season.

§ Data as to quantity produced and men employed were withheld in all cases.

PLATE 7.

COHOES COMPANY'S GATE HOUSE AND DAM, MOHAWK RIVER, AT COHOES, N. Y.

FLAGSTONE PRODUCERS AND PRODUCT.

QUARRY OWNERS.	Post-office.	Quarry, location of	Value of annual product.	Feet produced annually.	*Market.
J. N. Briggs	Coeymans	Alcove	$6,000 to $8,000		Albany, Troy, New York and other cities.
Lansing & Kniffin	Alcove	Alcove		5,000	Sold to dealers.
Applebee	Dormansville	Dormansville			Sold to dealers.
H. Steward G. Steward	South Berne	South Berne		150,000	Sold to dealers, but principally worked by dealers and others.
David Bailey	South Berne	South Berne			Worked irregularly.
James Cummings	Reidsville	Reidsville		10,000 to 25,000	Worked irregularly.
Chas. Brate	Reidsville	Reidsville			Worked irregularly.
Thos. Alexander	Reidsville	Grippey Hill		150,000	Worked by several parties; product sold to dealers.
John Flagler	Albany	Reidsville		10,000	Flags sold in Albany.
Perry Stewart	Reidsville	Reidsville			Quarry worked irregularly.
Fred Udell	Reidsville	Reivsville			Quarry worked irregularly.
Otto Brunt	Reidsville	Reidsville			Quarry worked irregularly.
Frank Kingsley	Reidsville	Reidsville			Quarry worked irregularly.
Wm. Sternburner	Reidsville	Reidsville			Quarry worked irregularly.

*The smaller quarries are worked irregularly by their owners and the product sold to dealers. The flags in many cases go direct to Albany, and are shipped thence to points of consumption. They are shipped by rail from Voorheesville and Coeymans.

MOLDING AND BUILDING SANDS — PRODUCERS AND PRODUCT.

PRODUCERS.	Post-office.	Kind of sand.	Kinds of castings used.	Quantity.	Markets.	Sand pits.
Whitehead Brothers	Albany	Molding	Brass, light and medium.	25,000 to 50,000 tons	All over U. S.	West Albany, Selkirk and Cedar Hill.
Bell & Brown	Catskill	Molding	Brass, light and medium.	20,000 tons	All over U. S.	West Albany, Selkirk and Cedar Hill.
F. S. Caldwell	Selkirk	Molding	Brass, light and medium.	10,000 tons	All over U. S.	Selkirk.
E. D. Ransom & Co.	Albany	Molding	Brass, light and medium.	....	....	
Van Rensselaer Sand Bank	North Albany.	Building	....	....	Albany	North Albany.
Charles Taylor	New Scotland	Building	....	....	Local	New Scotland.

ROAD METAL — PRODUCERS AND PRODUCT.

PRODUCER.	Post-office.	Quarry.	Kind of stone.	Use.	Quantity.	Men employed.	Markets.
P. Callanan's quarry	South Bethlehem.	South Bethlehem.	Limestone....	Macadam and cement, road metal and railroad ballast.	25,000 to 30,000 cubic yards.	50	Southern, Eastern and Middle States.

WATER POWER — USERS AND USES.

USERS.	Post-office.	Power supplied.	Total fall.	Use of power.	Hands employed.	Source of power.	Remarks.
Cohoes Company	Cohoes...........	10,000 F. P.	125 feet.	Knitting, spinning, electricity, etc..	15,000	Mohawk river.	Has power to spare; no steam used.
Kenwood grist mill.......	Kenwood	75 F. P.	20 feet.	Grist	....	Normanskill..	
Kenwood felt mills.*......	Kenwood	75 F. P.	20 feet.	Felt	....	Normanskill..	Steam used.
Grist mill	South Berne......	....	....	....	....	....	
Grist mill	Rensselaerville ...	....	....	....	....	....	
Saw and grist mill........	Dormansville	....	....	....	....	....	

* Burned since the preparation of this report.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF ULSTER COUNTY.

JAMES HALL, State Geologist. | N. H. DARTON, Assistant.

1892-1893.

PLATE 1.

Overlook Mountain and Front of Northern Catskills. From West Hurley, Looking North. (In the Text of this Paper, the Author Specifies as Plate 1, a Stereogramic Map of Ulster County, but no such Map was Furnished with the Report, and the above View was Found with this Numbering.)

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

Preliminary Report on the Geology of Ulster County.

By N. H. DARTON.

CONTENTS:

JAMES HALL, *State Geologist:*

SIR.—Ulster county is in central southeastern New York and occupies an area of approximately 1400 square miles.

It extends from a frontage along the Hudson river about thirty-seven miles westward into the southern Catskills. To the south it is bounded by Orange county, to the southwest by Sullivan county, to the northwest by Delaware county, and to the north by Greene county.

The area of Ulster county presents a considerable diversity of topographic features, comprising mountains of several kinds, hills and ridges in great variety, valleys of a number of types, terraces, glacial phenomena and drainage in various stages of development.

In plate 1 an attempt has been made to represent the principal physiographic features of the county by a device known as a stereogramic map. The stereographic lines of which this map is constructed, define profiles drawn at such frequent intervals that with some additional shading they give a pictorial effect.

The western portion of the county is occupied by the southern portion of the Catskill mountains, which cover about half of its area. From the foot of the Catskill mountains there is a region of high plateaus which extend eastward for some distance and terminate in a steep descent to a valley occupied in greater part by portions of the Rondout and Esopus creeks. East of this valley there is a series of ridges of greater or less height which expand and rise into the Shawangunk* mountain southward. These ridges are parallel to the Hudson north of Kingston and separated from the river bank by a terrace of moderate height. The Shawangunk mountain extends to the southward across the southern half of the county and is separated from the Hudson valley by the wide valley of the Wallkill and a series of narrow ridges extending from south of Rondout to west of Marlborough. Between these ridges and the river there is a high undulating terrace which terminates in steep slopes or rocky faces along the river shore.

The Catskill mountains are a complex of ridges becoming very high, rounded or terraced summits. These summits are separated by depressions of various sizes and the ridges are separated by deep valleys, of which many head in relatively low divides. Originally the region was a plain and there may be minute remnants of this plain on some of the higher summits, but elsewhere it has been removed by erosion, and the present surface of the region consists entirely of long, steep slopes.

The greater part of the Catskill mountains in Ulster county is confined to the southern Catskills or Shandaken ranges, which are separated from the northern Catskills by the deep, wide valley of Esopus creek. In the northern townships there are Overlook and Rose mountains and some of the lower ridges lying on the slopes of the northern Catskills. The altitudes of the principal high summits are given in the following table, which is taken from Guyot's memoir.†

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* The pronunciation of this Indian name is *Shongum*, according to local usage.

† Physical structure and hypsometry of the Catskill mountains, Am. Jour. Sci., 3d series, vol. 19, pp. 429–451.

	Feet.		Feet.
Slide mountain	4205	Panther mountain	3828
Peak-o-moose	3875	Spruce top	3567
Table mountain	3865	Eagle mountain	3560
Graham mountain	3886	Balsam mountain	3601
Double top	3875	Belle Ayre mountain	3394
Lone mountain	3680	Overlook mountain	3150
Mt. Cornell	3881	High Point	3100
Wittemberg mountain	3778		

The larger valleys of the Catskills are those of the Esopus creek and the lower portions of some of its branches, Rondout creek, the branches of the Neversink and Dry brook. They are deep and steep sided but contain flats of greater or less width at the bottom. The slopes consist of alternations of irregular rocky ledges usually in more or less continuous terraces, with intermediate slopes of varying degrees of steepness. The low divides at the heads of the principal streams and certain of their branches are very remarkable features of physiography of the Catskills and their origin is not entirely clear. They are air gaps having a depth of nearly 2000 feet in the case of Stony Clove and they afford the principal means of communication through the ranges. The divide in Stony Clove is 2100* feet above tide level; the gap at Pone hill, 1886 feet; Mount Hollow. 2650* feet; divide between Big Indian and East Branch of Neversink, 2700† feet; West Branch of Neversink-Beaverkill divide, 2650† feet; Peak-o-moose gap at head of Rondout creek, 1640† feet; Kaaterskill-Schoharie creek divide, 1925* feet; Plattekill-Schoharie divide, 1925* feet, and there are many others which are more or less distinctly indicated in plate 1. Stony Clove, "Peak-o-moose" gap, Mink Hollow and Deep Hollow gaps are very narrow rocky gorges with walls rising steeply 1200 feet or more, and long steep slopes above to the level of the adjoining summits. The others are wide depressions with slopes of various degrees of steepness. Excepting in the Plattekill and Kaaterskill divides the slopes are from the center of the gaps and about the same in degree in either direction. The Plattekill and Kaaterskill have cut deep gorges in the steep eastern slope of the northern Catskills which head in

* U. S. Geol. Survey determinations.
† Aneroid determinations by N. H. Darton. The others are from Guyot.

the wide gently west sloping valley of the two head branches of the Schoharie creek. They present an unsurpassed illustration of stream-robbing, for they have cut off the upper waters of these Schoharie branches and carry them directly to the Hudson. This is also the case with the Sawkill in the center of Woodstock township, where it has tapped the headwaters of the Beaverkill over falls into a gorge with walls 800 to 900 feet in height.

The steep eastern front of the Catskill mountains is one of their most notable features and it adds greatly to their prominence. In the northern Catskills the front rises abruptly from 1500 to 2500 feet out of a plain of which the average altitude is about 450 feet above tide level. It is a relatively even slope comprising a great succession of steep, narrow terrace scarps which are broken only by the Kaaterskill and Plattekill gorges. In the southern Catskills the front has a similar abruptness but its slope is broken by long spurs.

The belt lying east of the Catskills is a high plateau with its surface broken by low, wide terraces and it is crossed by the streams in deep rocky gorges. It is terminated eastward by very steep slopes which extend across the country from northeast to southwest as a prominent escarpment. The valley at its foot is continuous across the county and is occupied in greater part by the middle portion of the Rondout creek and lower Esopus creek. The ridges eastward are a succession of long north and south trending ranges of moderate height. The eastward range presents a limestone cliff of greater or less elevation to the eastward through the greater part of its course. These ranges expand and rise into the Shawangunk mountain north of Rosendale, and this mountain is a prominent feature in the south-central townships. In its broader portion it comprises several ridges and attains an elevation of over 2200 feet. It has a slope westward to the Rondout valley and presents to the eastward a vertical escarpment of conglomerate surmounting long slopes of shales. It narrows greatly near the southern border of the county, and extends far to the southward as a narrow single-crested ridge with long western slope and an east-facing escarpment at the west of its eastern slopes.

The Wallkill valley region comprises broad belts of level or gently-rolling lands along the Wallkill, Swartzkill and Plattekill and rounded hills of moderate elevation on the adjacent slopes. Along the base of the Shawangunk mountain these hills increase considerably in altitude, but their rounded form is unchanged.

East of the Wallkill valley there rises the series of high ridges which constitute Marlborough mountain and its northern continuation to Hussy hill south of Rondout. They present considerable diversity in topography, but are mainly rocky and very steep sided. The higher ridges average about 1000 feet in altitude, but there are many irregularities in their course as shown in the stereogram. The deepest depressions across the range are west of Highland and Ulster Park stations.

General Structure.

The general structural relations of Ulster county are represented in sections of figure 1.

The rocks are a series of widely extended sheets of sandstone, shales, limestone and conglomerates. The uppermost or youngest member is on the higher summits of the Catskill mountains, and the lowest or oldest which appears on the surface, is a limestone which occupies a very small area in the southeastern corner of the county.

In the Catskill mountains and their foothills there are several thousand feet of sandstones and shales which are overlaid in the higher regions by conglomeratic sandstones. These beds all dip gently to the west-southwest, possibly with slight undulations. In the lower lands and ridges east of the Catskill mountains there is a succession of limestones and shales which to the southward are underlaid by a sheet of hard conglomerate which gives rise to Shawangunk mountain. In this belt the gentle westerly dip gradually gives place to flexures, some of which are of considerable steepness. The limestone series and Shawangunk conglomerate are underlaid unconformably by the shales and sandstones of the Hudson river formations which extend to the Hudson river. In the southeastern portion of the county the beds are steeply overturned and inclined mainly to the eastward.

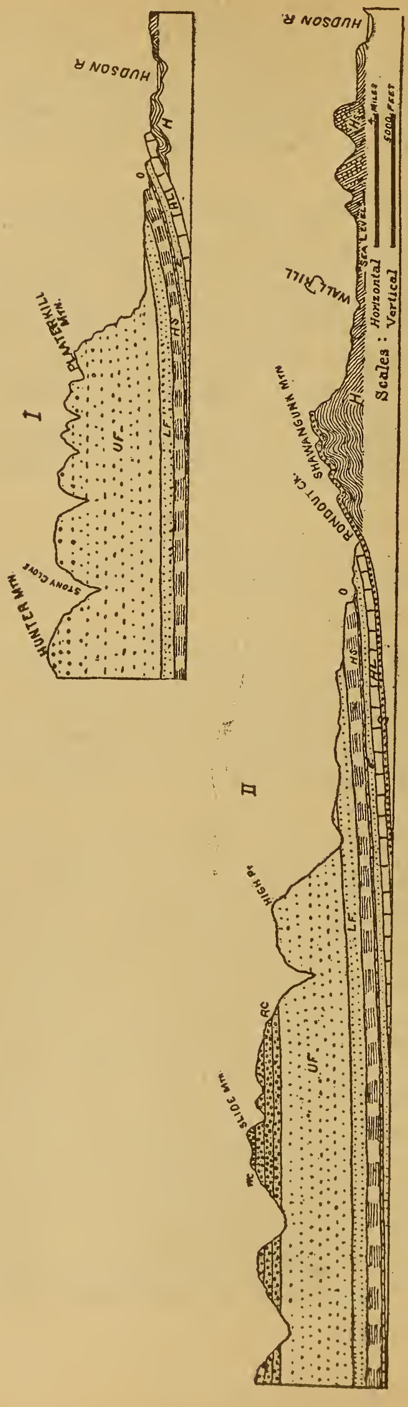


FIG. 1.—Cross sections of Ulster county. I. Through Saugerties township. II. Through Slide mountain near Highlands, looking north. WC., White conglomerate sandstone; RC., Red conglomerate sandstone; UF., Upper Flag series; LF., Lower Flag series; HS., Hamilton shales; O., Onondaga limestone; E., Esopus shales and Oriskany sandstone; HL., Helderberg limestone and Salina waterlime series, and including Niagara limestone on I and Clinton and Medina sandstone and shales on II; S., Shawangunk grit; H., Hudson river shales; Hs., Hudson river sandstones.

Along the river terraces and in the larger valleys there are extensive areas of clay and sands, and in nearly every part of the county there are accumulations of drift gravels and sands of greater or less extent.

Stratigraphy.

The rocks of Ulster county comprise formations from lower Silurian to upper Devonian age lying in two comformable successions separated by an unconformity at the top of the lower Silurian. These members, with their ages, thickness and general characteristics, are listed in their regular succession in the following table:

	Names.	Age.	Character.	Thickness.
Devonian.	....	Catskill........	White conglomeratic sandstones.......	350+
	....	Chemung.......	Red conglomeratic sandstones.........	1375+
	Upper Flag series.......	Oneonta (Portage)	Gray sandstones and flags, with red shales	3000+ 500
	Lower Flag series.....	Hamilton.....	Gray sandstones and flags, with black shales	600
	Hamilton shales.......		Black shales, with thin sandstones.....	
	Onondaga limestone	Onondaga	Gray cherty limestone	60
	Esopus shales	Caudi-galli grit.	Black slaty shales......................	200–300
	Oriskany sandstone	Oriskany	Calcareous sandstones and conglomerate	5–30
Silurian.	Upper shaly limestone		Impure limestone	30–125
	Becraft limestone		Limestone..............................	20–30
	Lower shaly limestone	Helderberg...	Impure limestone	60
	Pentamerus limestone.		Dark massive limestones...............	30–60
	Tentaculite limestone..		Thin-bedded limestones................	20–40
	Cement series	Salina	Cement and waterlime	20–50
	Niagara limestone.......	Niagara	Coralline limestone	0–8
	Clinton and Medina	Clinton–Medina.	Red shales, sandstones and quartzites.	0–45
	Shawangunk grit........	Oneida	Conglomerate	0–250
	Hudson River formation	Hudson River ..	Black shales and sandstone............	1800+
	Wappinger limestone ...	Calciferous	Limestone..............................	200+

White conglomeratic sandstone.— This formation caps Slide mountain and the summits of some adjacent peaks. It is a coarse-grained, heavily-bedded, moderately-hard sandstone containing disseminated pebbles and conglomeratic streaks. The pebbles are of quartz and quartzite in greater part, of light color and small size. Its greatest thickness is seen on Slide mountain, where there are 350 feet; the outliers or adjacent summits are very much less in thickness. The colors are in greater part very light gray, but some portions are greenish or brownish, particularly toward the base of the formation. There are several intercalated beds of somewhat finer-grained sandstones. The pebbles and conglomeratic streaks are of very irregular occurrence, but they exist in appreciable proportion in nearly every bed.

It is not, by any means, the highest formation in the Catskill mountains, and is probably a local development. This formation, and the underlying members to the base of the Upper Flag series, belong to the Catskill group of Mather and Vanuxem.

Red conglomeratic sandstones.— This member occupies the higher portions of the western townships. It consists of coarse, heavily-bedded sandstones of dull brownish hue, containing disseminated pebbles and conglomeratic streaks and only differs from the overlying white conglomeratic beds in its color. It should not be classed as a conglomerate for the reason that it is in greater part composed of sand grains. The pebbles and conglomeratic portions are scattered very irregularly through the series, but are nearly everywhere more or less conspicuous. The bedding is thinner and flaggy at some portions, and there is much coarser cross bedding. Locally there are included masses of more or less heavily-bedded gray sandstone, but these are of no great thickness, and are not conspicuous features. Several thin layers of red shales also occur. This series merges into the underlying Upper Flag series by a short, irregular transition which may vary somewhat in horizon. The thickness of the beds in Ulster county is about 1375 feet to the eastward and apparently somewhat more to the westward. The formation constitutes the higher slope of the Slide mountain ridge and all of the higher region west of the heads of Big Indian and Neversink creeks.

The Upper Flagstone series.— This formation consists of a thickness of thin and thick-bedded sandstones with intercalated red shales, occupying a wide area in the middle and lower portions of the Catskill mountains. The red shale intercalations are thickest and most frequent to the northwestward and in the lower members. Above and to the west and south they occur less frequently and in thinner beds. The sandstones occur in series from 20 to 200 feet in thickness, which give rise to sharp terraces in the northern slopes. They are in greater part light-gray to gray-brown in color and from two to six inches in thickness. Many of the beds are suitable for flagging or for "bluestone," and these are worked at numerous localities in the upper valleys of Esopus creek, and along the eastern slopes of the Catskills. Portions of the sandstones are in heavy masses with cross-bedded structure, and these members are usually of exceptional hardness. There are in this series occasional intercalations of dark-colored shales, but they are very infrequent, and I have not observed any of greater thickness than three feet. There are also local occurrences of conglomerated sandstone and scattered pebbles, some beds of which occur at two horizons on Overlook mountain. The red shales occur in beds varying from a few inches to thirty feet, but are usually not over ten feet. They are most frequent and extensive in Woodstock and adjacent townships. In the western part of the county there are red shales at long intervals among the upper members of the formation. In Wawarsing and Rochester townships there are several beds of red shales in the lower members. The thickness of the formation is about 3000 feet, but the precise amount can be determined only by careful, instrumental measurements. The members of the formation are nearly everywhere exposed within its area, particularly the harder sandstones, which give rise to cliffs of greater or less prominence. The finest successions of outcrops are in the valley of the Esopus creek, the upper valley of Rondout creek, the west branch of Neversink, the Rondout valley below Lackawack, and along the slopes of the northern Catskills in Woodstock township and west of Saugerties.

Lower flagstone series.— This series consists of beds of thin-bedded sandstones with intercalated beds of dark shales. It extends diagonally across the county from Saugerties to Wawarsing townships and constitutes a range of hills and terraces lying next east from the foothills of the Catskills. It is the principal source of the great bluestone product of Ulster county, and it contains a number of heavy beds of this material.

Sandstones constitute the larger portion of the series, and they give rise to terraces of greater or less width and height in the less disturbed portion of the region. They are in masses which vary from a few inches to forty feet in thickness but in greater part average from ten to fifteen feet. The color varies from greenish-gray to light bluish-gray but some portions are dark gray. The rock is mostly moderately fine grained, but the grain varies somewhat. The texture is porous and the hardness is high. The beds of which the masses are constituted vary from half an inch to a foot in thickness, the same bed often presenting considerable variability in this regard. The intercalated shales are in beds from a few inches to eight or ten feet in thickness. Their color is dark gray to black in greater part, but some portions are brownish or greenish. Among the upper members of the series there are several thin, discontinuous streaks of light greenish and reddish shales interbedded among the dark shales and constituting beds of passage to the overlying Upper Flag series.

Thin streaks of quartz conglomerate were noticed at several localities interbedded among the flags, notably in the lower beds of the Jocky Hill region

The flag beds are exposed over wide areas in the quarry districts of Saugerties, Kingston, Hurley and Marbletown townships where they dip gently to the westward. The heavy masses give rise to terraces separated by slopes of shale or the thinner-bedded, softer sandstones. In southern Rochester and Wawarsing townships the beds are tilted steeply to the westward and their outcrop belt is greatly narrowed. In this region their upturned edges give rise to a high, rough range of hills lying between the foot of the Catskills and the Rondout-Sandburg valley.

The thickness of the Upper Flag series is about 500 feet, but no careful measurement was made.

The age of the series is not definitely known, but it is in the main of the upper Hamilton group; the shales and some of the sandstone beds contain fossils, but these have not yet been studied.

Hamilton shales.—This formation consists of a series of dark-gray to black or brown shales containing thin sandy beds, particularly in its upper part. It constitutes the steep slopes rising from the wide valley of Onondaga limestone to the terraces and plateaus of the Lower Flag series. In Wawarsing township, where the beds are steeply tilted, all but its uppermost members are deeply eroded and underlie the western side of the Sandburg Creek valley. In Mount Marion southwest of Saugerties the formation attains its greatest prominence, rising in a steep face high above the limestone region eastward. The beds are nearly everywhere exposed excepting the basal members which usually underlie the western edges of the valley at the face of the slope. The immediately overlying beds give rise to frequent cliffs of moderate height, and in these there were seen alternations of harder and softer dark-colored shales with thin sandy intercalations.

The upper beds are harder and contain scattered flaggy layers capping the slopes and constituting terraces along them. The summit of the formation has been considered at the base of the heavy flag belts of the Lower Flag series, but this may vary somewhat in horizon through the length of the county. The thickness averages about 600 feet. The beds are of the age of the lower Hamilton group, but the precise equivalence is not known. Fossils occur sparingly throughout the series, but they have not as yet been systematically collected or studied.

Onondaga limestone.—The occurrence of this formation is of considerable economic importance, for it furnishes lime of excellent quality which has been burnt at many localities. It is also a source of building stone not only for local use but for the market. The formation is a light bluish-gray limestone, dense in texture, and in greater part massively bedded. It contains much chert mainly in thin beds and elongated lenses, but this is sometimes absent locally. The chert predominates in the upper beds, but it is also usually present in the lower beds. The basal layers of the Onondaga limestones are beds of passage from the preceding formation, and for several feet in thickness consist of intermixtures of clayey and sandy rocks which gradually emerge upward into the fine limestone. The top of the formation is rarely exposed and I found no outcrop in Ulster county owing to the drift filled valley which here always occupies the Onondaga-Hamilton boundary belt.

The outcrop of the Onondaga limestone is practically continuous from the northeastern corner of the county to Wawarsing township, through which outcrops are rarely observed. For the greater part of its course it dips west into the wide valley, across which rise the steep slopes of the Hamilton ridge.

About Kingston the outcrop of the formation widens greatly in the series of gentle folds which traverse the region and most of the upper part of the city is built upon its area. Southward by Hurley and Marbletown the formation is a conspicuous feature in the ridge sloping west to Esopus creek. Farther south its outcrops are widely scattered. North from Kingston there are extensive exposures along the West Shore railroad and for a short distance east nearly to Saugerties where the railroad turns off to the northeast. From west of Saugerties to Asbury, exposures are very conspicuous along and near the road passing through Cedar Grove and Katsbaan. The thickness of the formation is at least sixty feet in Ulster county and does not appear to vary in amount.

Cauda-galli grit=Esopus slate.— This is, in greater part, a hard gritty shale giving rise to ridges, not unusually of large size but characterized by sharp contour and generally occurring in considerable number across the breadth of the outcrop of the formation. The slate is dark in color, often pitch black when fresh, brittle but tough in texture and massively bedded. The bedding is seldom conspicuous, for the formation is traversed by a slaty cleavage which crosses the bedding plane at high angles and along which the material readily cleaves into slaty fragments. The bedding planes are not lines of ready separation. Where the surface of the bedding planes are exposed they usually present impressions of a characteristic fossil which gave the original name "Caudi-galli grit" to the formation. This, as its name implies, has the form of a cock's tail in general outline and is supposed to be due to a fucoid which has been named *Spirophyton caudi-galli.* The upper member of the formation merges into the Onondaga limestone as described above, but it is sharply separated from the underlying formation by an abrupt change in the character of materials. The finest exposures are in the hills south and east of Kingston and along Esopus creek above Saugerties. The nature of the latter is shown in plate 3.

Its extent is about the same as that of the Onondaga limestone or slightly greater, and its outcrop is along a parallel belt lying next east. It often constitutes the crest of the ridge with the Onondaga limestone lying on the slope westward. Its soil is usually very thin and barren. In Rochester and Wawarsing townships its upper members become harder and less broken by slaty cleavage This is notably the case at the falls caused by it a mile northeast of Pattankunk.

From Wawarsing township southward the rock is not exposed, so far as I know, but it underlies the Sandburg Creek valley.

The thickness in the northern part of the county is about 200 feet; about Kingston it is fully 300 feet, but southward it probably thins somewhat although beyond Rosendale I could find no complete sections from which an estimate of thickness could be made.

The Oriskany sandstone.—This thin but characteristic formation lies immediately beneath the Esopus shales, either at the base of the first Esopus shale ridge or constituting a narrow ridge just east or south. It appears to be continuous throughout Ulster county but in some regions is hidden by drift or debris. It presents a variety of components in this region, some of which were not observed elsewhere. In greater part it is a very silicious limestone, but about Rondout and Wilbur it contains a bed of small pebble conglomerate to which attention has been called by Davis.* The thickness of the formation is very variable. West of Saugerties, seven feet of quartzitic beds are seen; along Esopus creek there are twelve feet of calcareous beds, and at Rondout, thirty feet, including the conglomeratic member. In the Whiteport region and southward the formation consists of a silicious limestone bed which has a thickness of from eight to nine feet. Near Wawarsing the thickness is ten to fifteen feet. The formation is very fossiliferous throughout; the casts and impressions of the shells appearing prominently in the weathered surface of the beds. The most notable occurrence of fossils is along the east bank of Esopus creek below Glenerie, where they abound. They are also abundant at some points about Rondout and along the Wallkill Valley railroad, north of Whiteport.

Upper Shaly limestone.—This is the upper member of the lower Helderberg limestone formation.

The upper Shaly beds are very impure limestones containing a considerable proportion of clay and sand. They are somewhat massively bedded, but their most prominent physical feature is their slaty cleavage. Owing to their hardness

* Nonconformity at Rondout. Am. Jour. Science, III, vol. 26, page 392.

and the cleavage they give rise to small, very rough ridges similar to those of Esopus shale, but usually of even rougher surface. In some regions they constitute the steep eastern face of a ridge of which the crest and western slope are Oriskany sandstone. Notwithstanding the slaty cleavage the beds are everywhere fossiliferous but the remains are often much distorted. The thickness of this member is about 125 feet in the central and southern portion of the county, decreasing gradually in the Saugerties region to from thirty to thirty-five feet, near the Greene county line. The upper Shaly limestone appears to merge into the Oriskany beds at some localities, but it is quite abruptly separated from the Becraft beds below.

The Becraft limestone.— These are thick beds of a relatively pure, light bluish-gray to pinkish-gray limestone of semi-crystalline grain, and made up in considerable portion of shell and shell fragments. Among these fragments there are characteristic saucer-shaped masses of white crystallized carbonate of lime mostly from an inch to two inches in diameter representing the bases of the heads of crinoids. These were regarded as Scutellæ [from their form only] by some of the earlier observers, and their conspicuous occurrence in this member gave the original name of "Scutella limestone." The thickness of the formation averages from twenty to thirty feet. It is quite extensively worked for lime burning near Rondout and Whiteport and affords excellent lime. In plate 5 there are shown some of its features in a quarry near Rondout.

The Becraft limestone extends in a narrow but continuous band entirely through the eastern part of the county. Its most prominent exposures are between Saugerties and Rondout, and about Wilbur and Whiteport. It is rarely seen to the southwestward where an outcrop at Millhook and another a mile southwest of High Falls are the principal exposures.

Lower Shaly limestone.— This formation is precisely similar to the upper Shaly beds and the two members are co-extensive in Ulster county. The thickness averages from sixty to seventy feet throughout. The very rough little ridges to which this formation gives rise are particularly conspicuous in the Binnewater region where they are repeated by many small folds and are very steep and craggy. The beds are extensively exposed about Wilbur and Rondout and along the crest of the limestone ridge extending from Rondout to Saugerties.

Pentamerus limestone.— This member is a hard, dark blue or lead colored, somewhat cherty, massively-bedded limestone, which gives rise to conspicuous cliffs throughout the greater part of its outcrop. These cliffs are due mainly to the toughness and massiveness of the beds together with a disposition to vertical jointing, and the presence of underlying beds of much softer texture. Another characteristic feature is a sub-bedding along irregular waving lines which are brought out by weathering. The limestone is sparingly fossiliferous, containing principally the characteristic *Pentamerus galeatus* which was seen in all localities.

The most prominent exposures are the cliffs at Rosendale and northward, about Port Jackson, near Eddyville and along the eastern face of the limestone ridge extending from Rondout to Saugerties and West Camp. These cliffs vary in height, but are usually continuous for long distance. Two miles north of Rondout they approach to within a few yards of the shore of the Hudson but to the northward they trend farther back and are separated from the river banks by a terrace averaging somewhat over a mile in width. In the widely corrugated region about Rosendale, Whiteport and the Binnewater, the exposures are extensive. Along the axis of the principal anticlinal in this region, the beds rise in high ridges for some distance.

The thickness of the Pentamerus limestone is variable. About Kingston and northward it is from thirty to forty feet. About Whiteport the same, and at Rosendale considerably more, attaining a maximum of sixty feet. To the southwestward its full thickness is not exhibited.

Tentaculite limestone.— This is in greater part a thin-bedded, dark-blue limestone constituting the basal members of the Helderberg limestones. The beds are for the most part from two to three inches thick and they separate along smooth bedding planes. The formation has a thickness of from twenty to forty feet, its greatest development being in the vicinity of Rosendale and Rondout. There is included at or near its base, notably in the quarries near Rondout, a dark-gray, impure limestone containing many corals and representing the Stromatopora horizon. The Tentaculite beds appear to be continuous throughout, but they are usually hidden by the talus from the Pentamerus cliffs above, and outcrops are rare. They are well exposed in the cement quarries at Rosendale, Whiteport, East Kingston and Rondout, and also near West Camp.

The Salina waterlime beds.—These members are a southeastern extension of the Salina formation of central New York, and the cement beds which they here carry are the most important mineral resource of Ulster county. The usual characters of the formation are thin-bedded water limestones and the cement is of local occurrence. It is a blue black, very fine grained, massively-bedded deposit, consisting of calcareous, magnesian and argillaceous materials in somewhat variable proportions. The beds are extensively developed in the Rondout and Rosendale regions. They come in gradually and are attended by a thickening of the formation from its usual average of twenty to thirty feet to forty or fifty feet. At Rondout the principal cement bed has a thickness averaging about twenty feet. It lies directly on the coralline (Niagara) limestone and is overlaid by alternating successions of waterlime and thin impure cement beds. The cement horizon is not exposed far north of East Kingston, but how far it extends to the northward is not known. It is seen to thicken southward and it attains its maximum thickness in the vicinity of Rondout, thinning out again and giving place to waterlime beds south of Wilbur. It is seen to have come in again in the Whiteport anticlinal, which brings up a great development of cement beds along its principal axis from Whiteport to Rosendale. Some features of the beds in this region are shown in the plates. They also come out along the eastern limb of the synclinal eastward. To the south of Rosendale the cement beds continue up the Coxingkill valley and around the point of the anticlinal by High Falls on the Rondout creek. Above this place it can be traced but a short distance owing to its deep erosion and heavy drift cover in the Rondout Creek valley, but its reappearance near Port Jackson indicates that it probably continues for a considerable distance.

In the Whiteport–Rosendale region there are two beds of cement, the lower averaging twenty-one feet in thickness, and the other averaging twelve feet in thickness with an intervening member of ten to fifteen feet of waterlime beds, but these amounts vary considerably. At High Falls the upper bed is fifteen feet thick, the lower bed five feet thick with three feet of intervening waterlime beds. The High Falls are over the thicker bed as is shown in the plates. Cement may be looked for in the upper Rondout valley, from Port Jackson by Ellenville, but owing to absence of outcrops this should only be regarded as a suggestion.

The Coralline limestone (*Niagara limestone*).—This is a thin bed of dark-gray limestone which underlies the cement at Rondout and for a short distance northward. In the Rondout quarries its thickness is about seven feet. At the entrance to the quarries in Becraft limestone, a mile north of East Kingston, it is seen to have thinned to five inches. To the northward there are no exposures of this horizon except near the railroad north of West Camp station, where the member is seen with the thickness of three feet. South of Rondout, in the Whiteport and Rosendale regions, it is absent for the cement is seen lying directly on the surface of sandstones of greater age. The corals in this limestone are of Niagara age, as Dr. James Hall has long ago shown, and this thin bed is the attenuated southeastern extension of the great limestone series which gives rise to the Falls of Niagara.

Clinton and Medina formations.—The beds which are thought to represent these horizons begin a few miles south of Kingston and extend through the Whiteport-Rosendale cement region and up the Rondout Creek valley to Homowack. They present considerable diversity in character. The lower member is red or reddish shale throughout, but the upper beds vary from quartzite northward to shaly and calcareous beds southward.

The formation comes in between the waterlime and Hudson river slates along the base of the ridge, about midway between Wilbur and Eddyville, and thickens gradually to the average of about forty feet in the next five miles. The upper member of white or gray, thin-bedded quartzite begins first and is followed in a couple of miles by an underlying series of hard shales varying in color from dull red to brown. These two members preserve their distinctive characters to some distance beyond Rosendale, where the quartzite gives place to argillaceous and calcareous sediments.

The quartzite is in very regular beds having a thickness from three to twelve inches which are in greater part welded together. The predominating color is light-gray with buff-brown streaks; many of the beds having a characteristic cross-bedding within themselves brought out by slight differences in tints. The lower cement bed lies directly on the surface of this quartzite, but is sharply separated by dissimilarity of materials without beds of passage. The shales underlying the quartzite are in greater part dull-red in color, moderately fine-grained, and massively bedded as a whole, but they readily break into shale on exposure. They are quite sharply separated from the quartzite.

The shales and quartzites are extensively exposed in the cement quarries along the anticlinal of the Rosendale-Whiteport belt and the eastern edge of the synclinal eastward. The two members preserve their distinctive characters to some distance south of Rosendale, where the quartzite gives place to argillaceous and calcareous sediments finely exposed in the north bank of the Rondout, at High Falls. In this region the red of the lower shales increases to a bright tint, which is strikingly exhibited in the High Falls exposure. There are also outcrops of these red beds on the Coxingkill, two miles south-southeast of High Falls, and on the point of an anticlinal near Stony creek, a mile southeast of Port Jackson. Exposures of the members are rare in Wawarsing township, but at several points south of Ellenville there are a few small showings of red and brown shales along the western base of the Shawangunk mountain.

The evidence as to the precise equivalency of these beds between the Shawangunk grit and Salina formation, in Ulster county, is unsatisfactory. No fossils have been found and the physical characters are not wholy distinctive. The quartzite and calcareous upper member is thought to represent the Clinton formation, for the upper part of this horizon is characterized by somewhat similar beds in western New York. The lower red beds may also be Clinton, but as they appear to expand into a series of red sandstones southward, it is suggested that they are of Medina age.

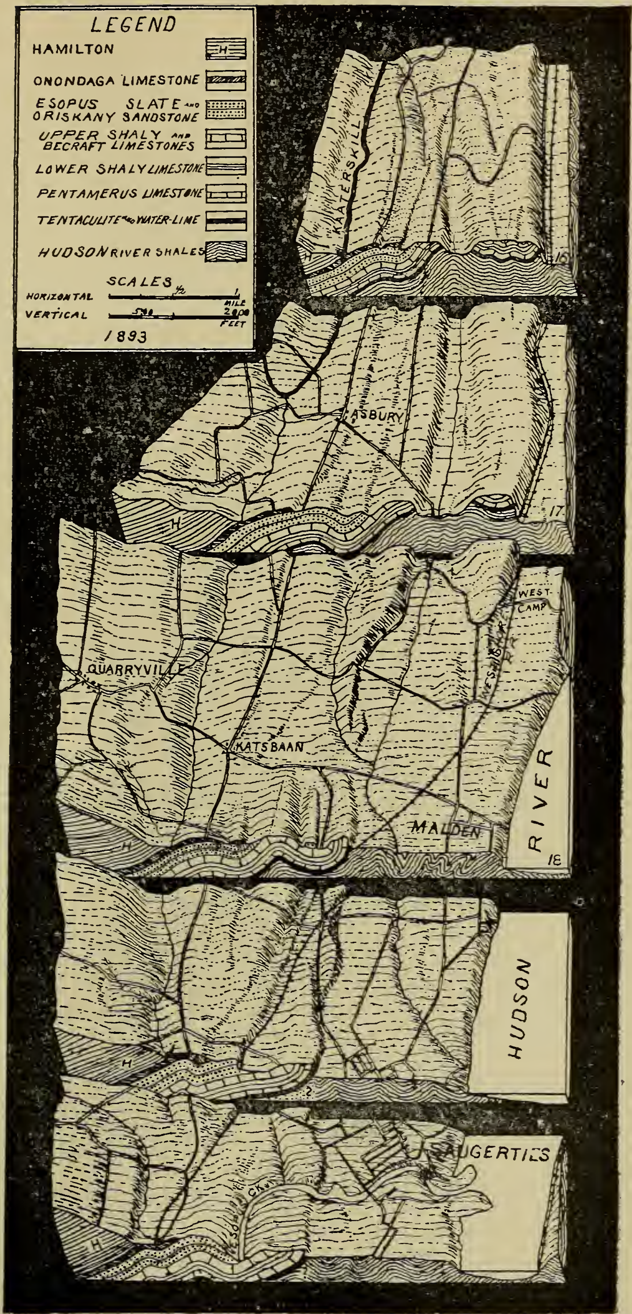
Shawangunk grit.— This formation is a great sheet of silicified quartz conglomerate lying on the Hudson river shales, and giving rise to the Shawangunk mountain. The first appearance of the formation northward is between Binnewater and Whiteport stations, on the Walkill Valley railroad, and in the cement quarries on the eastern side of the ridge eastward, as before noted. In the anticlinal north of Binnewater station, the thickness rapidly increases to sixty feet, but to the eastward it thickens less rapidly and it is discontinuous at several points. Just south of Rosendale it thickens rapidly from east to west to about forty-five feet, and to 100 feet in the ridges which rise to the southwest. About Lake Mohonk fully 160 feet are exposed and at the falls of the Peterkill there are 210 feet in all, but these are localities at which the upper part of the formation has been removed by erosion. The thickness of the formation in the wider part of the mountain is about 200 feet, for on Sam's Point and Millbrook mountain the precipices expose fully this amount. Along the western slope near Ellenville 200 feet seems to be a fair estimate; and the entire thickness is here exposed, but I made no precise measurements.

In greater part the rock consists of white quartz pebbles of small or moderate size in a matrix of sand and silicious cement. Locally there are beds of coarse quartzite or quartzitic sandstones, but the conglomerate is the predominant rock. The color is white, with local exceptions of gray, blue or buff, the latter due mainly to staining from pyrites which is frequently disseminated in the rocks. The bedding is predominantly massive, averaging three to four feet, but thinner bedding is sometimes seen particularly in the finer-grained materials. The most conspicuous exposure of thinner bedding is at Awosting or Peterkill falls as shown in an accompanying plate.

The unconformity.— Throughout Ulster county there is unconformity between the upper and lower Silurian sediments, but its amount varies considerably. In the northeastern townships the attenuated eastern representative of the Niagara limestone lies unconformably on the Hudson river shales and the Clinton, Medina and Oneida deposits are absent. South from Rondout the supposed representatives of the Clinton, Medina and Oneida formations come in, in succession, and the Niagara limestone is lacking. In the southern part of the county, where the Shawangunk grit attains great thickness, it lies on an eroded surface of the Hudson river shales throughout. These relations are due to an uplift with erosion at the end of lower Silurian times and probably also to oscillations for a considerable part of the early upper Silurian. Mather and Davis have discussed some of the relations in the Hudson valley, and Dr. James Hall has reviewed the principal features in several papers.

The sequence of events in Ulster county was a general uplift of the deposits at the close of the Hudson river deposition, and erosion of its entire surface. The uplift was attended by considerable folding, the greatest in amount to the northwestward and the flexures were base leveled in some measure. The Oneida, Medina and Clinton appear to have been deposited during subsidence which increased southward so that the deposits overlapped, the latest extending nearly to Kingston. Possibly there was some deposition farther south which was removed by uplifts and erosion of which there is now no evidence. The absence of the Niagara southward, and its thinning north of East Kingston, may be due either to cessation of deposition, or to uplifts of the surface above the waters of Niagara times. With the deposition of the Salina beds there was general subsidence which was long continued.

Hudson river formation.— This formation consists of shales and sandstones. The shales vary from gray-brown to black in color, are fissile, moderately hard for the most part, and give rise to rounded hills which, in the vicinity of Shawangunk mountain, are of considerable height. They contain intercalated beds of sandstone of two kinds, one a very fine-grained, massively bedded, dark-gray or blue-black hard sandstone, of which there are beds occurring widely scattered throughout the formation; and the other, a succession of coarse-grained, dark gray, thin-bedded flaggy sandstones with disseminated pebbles of quartz, slate, and limestone occurring in a series of ridges extending northward through the southeastern corner of the county. The stratigraphy of the formation has not been worked out, and owing to the complicated structure and lack of knowledge of the stratigraphy, the thickness of the formation in Ulster county has not been determined.



Stereogramic Map and Sections of the Northeastern Part of Saugerties Township.

Wappinger limestone.— This formation occupies a very small area in the southeastern corner of the county, south of Marlborough. It consists of light bluish-gray limestone-containing considerable arenaceous material and closely resembling the purer varieties of the Calciferous sandrock of the Mohawk valley in its general appearance. It has the same dull gray glimmering fracture and similar cavities containing calcite and quartz, and weather to a dull buff tint. The beds are three to four feet thick in greater part, with some shaly streaks showing near the lowest exposures. The thickness above the surface is 150 feet, of which the lower fifty feet outcrop in a cliff along the Hudson river. The formation is the oldest in the county, and its age is upper Cambrian. The beds intervening between the Wappinger limestone and the Hudson river shales are cut out by the fault which has brought the limestone to its present position.

LOCAL GEOLOGY.

The limestone belt from West Camp to Katrine.— In plate 2 there is given a series of cross sections illustrating the principal structural features from several miles above West Camp to a short distance south of Saugerties. The salient features of this portion of the belt are the anticlinal valley and the geosynclinal ridge which end near West Camp, and the anticlinal ridge southeast of Katsbaan. The geosynclinal ridge is considerably eroded near West Camp and contains only a small thickness of lower Shaly beds at the county line. The Pentamerus beds are bared over a considerable area southward and terminate to the east and west in cliffs of considerable prominence. At the base of the cliffs on the east side, just west of the railroad, portions of the Tentaculite and waterlime beds are exposed having an aggregate thickness of about sixty feet. The waterlime beds are not fully exhibited, but there are no traces of cement rock apparent. Underlying them there is exposed at one point a three-foot bed of light blue-gray, tough, massive limestone containing corals of Niagara age. On the west side of the ridge the limestones dip to the west-northwest; on the western side to the east, both at low angles and with a perceptible pitch to the north.

Along the base of the ridge sandstones and shales of Hudson river age are seen with dips essentially the same as those of the overlying limestones. The contact was found. Opposite West Camp station the several limestones end in succession and the elevation of ridge is considerably decreased. It continues for about a mile presenting frequent outdrops of Hudson river shales and fine-grained gray-brown sandstones. Half a mile south of the termination of the limestones the Hudson river beds present a continuation of the synclinal with dips to the eastward of forty degrees to fifty degrees on the west side and a gentle anticlinal on the eastern side.

The anticlinal valley west of the geosynclinal ridge is flat bottomed with many small ridges of Hudson river shales and sandstones occurring at intervals. This valley widens southward and merges into the high terrace level which extends to the bank of the Hudson river. On its west side there are low cliffs of waterlime, Tentaculite and Pentamerus limestone which dip off to the westward, as shown in the section (plate 2). These cliffs have Hudson river slates and sandstones at their base for some distance. But basal contacts were not found here nor for several miles southward, and it is not known whether the coralline (Niagara limestone) is present. Above the crest of this ridge the lower Shaly, Becraft, upper Shaly and Oriskany are more or less widely exposed. On the west side there is a valley mainly in lower beds of the Esopus shales, and this formation extends therein to the road from Asbury to Katsbaan. At Asbury the Onondaga limestones are exposed over a considerable area on the summit and slopes of the ridge sloping to the Beaverkill, beyond which rises the steep slope of the lower Hamilton hills.

The Pentamerus outcrop extends southward to the western part of the village of Saugerties, with the overlying limestones exposed in the crest or on the western slope of the ridge. At a point about a mile and a half south of West Camp station a small fold crosses the belt and gives rise to a noticeable offset in the line of Pentamerus ledges. A short distance south of this there is a depression in which a small stream crosses, and two miles north of Saugerties the ridge is crossed by the West Shore railroad in a low gap with sloping sides. The Esopus shales extend southward in a broad belt which is crossed by the railroad opposite Saugerties. The breadth of this belt is due to two folds of which the anticlinal pitches up for some distance east of Cedar Grove, bringing the Oriskany sandstone, upper Shaly beds and Becraft limestone to the surface in a ridge of some prominence. This ridge is crossed by the upper road from Saugerties to Cedar Grove, on which the formations are well exhibited. The structure of this ridge to the westward is shown in section 18, plate 2. On the section there is a small synclinal tongue of the lower beds on the Onondaga limestone with a narrow strip of the Esopus shales in a valley beyond. This synclinal pitches down to southward and the limestone area extends eastward nearly to Saugerties station. At this station and in the railroad cuts near by, there are excellent exposures of the Esopus shales. They are black, massively bedded and have very distinct cleavage, nearly vertical to the bedding planes. Along the western slope of the ridge east of the station the Oriskany beds outcrop for some distance, and also on the roadside about a mile to the north. They are hard quartzites, eight feet in thickness with a dip to the west of fifty degrees. The underlying Shaly and Becraft limestones outcrop almost continuously in this ridge. Both are highly fossiliferous and very characteristic. There are a number of sharp variatious in strike in this vicinity as well as abrupt changes in dip. The lower limestone members on the eastern side of the ridge dip at angles of from twenty degrees to thirty degrees. This dip, which increases to fifty degrees or sixty degrees on the western side of the ridge, soon gives place to gentler dips farther westward. Three-fourths of a mile east of Katsbaan, one of these abrupt changes in dip is finely exhibited in an old quarry in Becraft limestone at the road-forks.

On the road from Saugerties northwestward, a quarry has recently been opened for the production of road metal. It is in the Pentamerus and Tentaculite beds, which afford a superior material for this use. The limestones are much broken and fissured in this vicinity and the fissures are largely filled with veins of calcite.

The Onondaga limestone, west of Saugerties, extends along the road from Mt. Marion to Asbury in a belt averaging a quarter of a mile wide, lying on the eastern slope of the Beaverkill valley. Exposures are almost continuous and some interesting features are presented. The most prominent outcrop is a line of low picturesque cliffs extending along the road for some distance south from Katsbaan. The limestone has been employed at several points for the manufacture of lime for local use. Near the road-forks west of Saugerties station there is a quarry in beds which are relatively free from chert. The rock is moderately hard, but owing to a tendency to vertical jointing and well-developed bedding planes it is easily dressed. Its color is a light blue-gray of very pleasant tint. The available beds of this quarry have a thickness of six or seven feet and these are accessible over a considerable area. A short distance southwest of Saugerties station, the railroad passes through a cut in the lower beds of the Onondaga limestone and runs on this formation from there to Kingston. The relation of the Esopus shales to the overlying limestones is well exhibited in this railroad cut. The black, slaty shales become lighter colored and calcareous, gradually lose their cleavage and give place to the argillaceous limestones of the base of the Onondaga. The limestones are exposed in the ridge east of the railroad to Mt. Marion station, south of which they are seen at frequent intervals in the railroad cuts. They dip gently to the westward into a wide valley filled with superficial formations, from which the Hamilton shales rise in high hills to the westward. In cuts adjoining the railroad bridge over Esopus creek, the impure basal limestones are again seen overlying the Esopus beds. The falls of the Esopus at this point are over a ledge of Onondaga limestone into a pool excavated in the beds of passage, and the Esopus shales are finely exhibited in the banks below. A short distance south of the falls a shallow synclinal is seen near the eastern edge of the limestones, but along the railroad the beds have their usual dip to the westward at angles of from three to fifteen degrees. Half a mile north of Katrine station the cherty beds of the limestone are exposed in a railroad cut. Their appearance at this point is shown in the following figure.

FIG. 3.—Chert layers in Onondaga limestone in cut of West Shore railroad, one mile north of Katrine station, New York.

West of the valley and flats underlaid by the Onondaga limestone there rise deep slopes of Hamilton shales which are remarkably continuous. These slopes rise 200 feet or more to terraces or a terrace-level of the harder flaggy beds of the overlying rim. Several creeks flow across this Hamilton shale region, of which the largest are the Sawkill and Plattekill, and these afford fine exposures of the formations. One particularly fine area is on the Plattekill a mile west of Mt. Marion station. Mt. Marion is of Hamilton rocks with a cap of flags.

The ridge of Helderberg limestones is deeply trenched by Esopus creek at Saugerties. To the southward it rises again, presenting a cliff of moderate height toward the plain eastward. On its westward slope there are outcrops of the upper Shaly and Oriskany formations, the latter sloping down to Esopus creek, to the west of which rise cliffs of Esopus shales. The relations of the Oriskany to the overlying formation along this creek are shown in plate 3.

In this illustration the Oriskany is seen in the low reefs to the right, with a reef of a harder bed of Esopus shales and steep banks of the slaty members on the left. The coincidence in the course of the creek with the strike of the rocks is a noteworthy feature, which is continued for over three miles. Near the road forks, a mile west of Glasco landing, the Helderberg beds are traversed by an anticlinal and synclinal entering the belt from the north-northeast. These give rise to small offsets in the line of cliffs, and the belts of outcrops at the gap through which the road passes to Mt. Marion station. These flexures widen and deepen southward, giving rise to considerable complexity in the distribution of the formations which they traverse. Their relations for the first three miles are shown in the following figure.

The distribution of the formations in this region is shown with considerable distinctness in the geologic map. The Becraft limestone is prominently exposed in this belt in cliffs twenty to thirty feet in height. It is of a light color, massively bedded, semi-crystalline in grain and very fossiliferous. The Oriskany is also exposed in great force and is remarkably fossiliferous. It is a silicious limestone with occasional streaks of chert, which is deeply weathered to a light snuff-colored, spongy rock, filled with casts and impressions of fossils. It is best exposed along the east bank of Esopus creek, below Glenerie, where the fossils occur in the greatest profusion along the road. As shown in the sections, the beds gradually pitch to the southward, and a mile north of Lake Katrine, the Oriskany sandstone pitches beneath the Esopus shales. This formation extends to the southward in a broad belt of rough ridges in which the flexures continue to the Kingston region. This belt has a high monoclinal ridge along its east sides constituted by Oriskany sandstone and the Helderberg limestones.

The Hudson river formation from West Camp westward is in greater part overlaid by clays and sands which constitute terraces extending from the high banks of the Hudson river to the ridge of Helderberg limestones. Along the banks of the Hudson and in the creeks which empty into it, there are many exposures, notably in the eastern part of the village of Saugerties. The formation consists of slates with interbedded, fine-grained massive sandstones, in layers from two inches to four feet in thickness. The slates vary from dark gray to black in color, and the

PLATE 3.

Esopus Slate on West Branch of Esopus Creek, above Saugerties, N. Y. Looking Down the Creek from the Bridge, One Mile East of Mt. Marion Station. Reefs of Oriskany Sandstone on the Right.

sandstones are of somewhat lighter tints. At the base of the Helderberg limestones the Hudson river rocks are exposed at only a few points. The localities near West Camp have been referred to, and there are a few others southwest of Glasco but their relations are not clearly exposed.

KINGSTON REGION.

In the Kingston and Rondout region the geology is particularly interesting and important. The cement beds are extensively mined and a series of flexures give considerable complexity to the relations of all the members. Prof. W. M. Davis* has given a brief description of a portion of the region, and a map showing some features of the distribution of the formations.

Mr. Lindsley† and T. N. Dale‡ have described some of the relations at the cement quarries.

In the map and sections, plate 3, are given the data which were obtained in the region, and I believe they will fully illustrate the general relations.

The principal features are the flexed, steeply-dipping monoclinal of the formations from the Salina to the Oriskany; the centroclinal area east of Wilbur which contains Esopus shales, and the corrugated folds of Esopus shales westward, containing a wide area of gently-folded Onondaga limestones, on which the greater part of the city is built. In this region there are many fine exposures of all the members, in numerous road, stream and railroad cuts, quarries and natural outcrops.

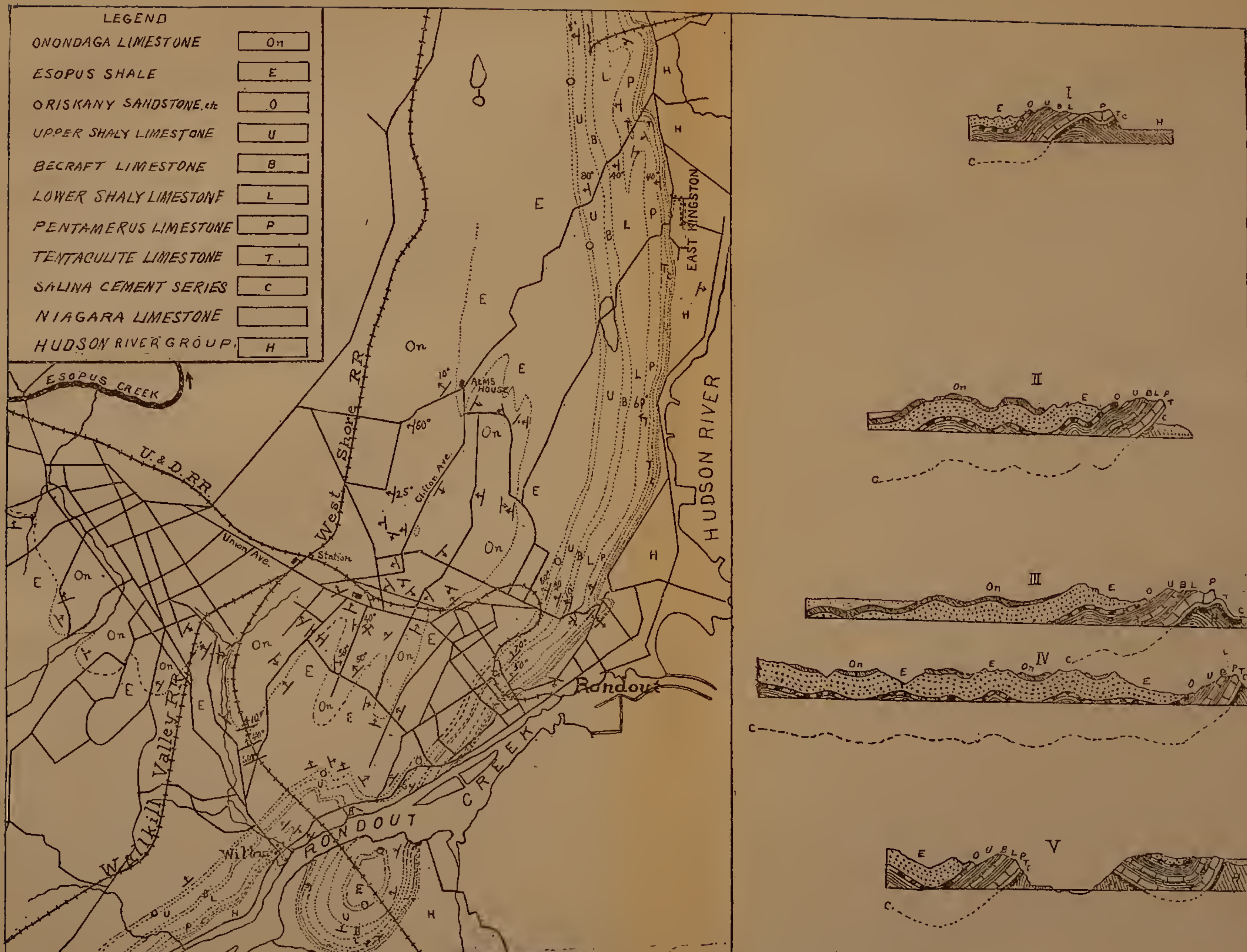
In the first section, on plate 4, are represented the relations which prevail northward to beyond Lake Katrine. A short distance south there are a series of excellent exposures into the eastern side of the ridge along an old tramway, and in an abandoned quarry to which it leads. The quarry is in the Becraft limestone which has been extensively excavated for lime burning. It is in thick beds dipping very gently westward. The lower limestone members are exhibited lying on the Hudson river slates in the railroad cut and some old cement openings near the turnpike. There is a four to six inch bed of impure ferruginous limestone

* The Nonconformity at Rondout; Am. Jour. Science, 3d series, vol. 26, pp. 389–395.
† Poughkeepsie Soc. Nat. Science, Proc., vol. 2, pp. 44–48.
‡ Am. Jour. Science, 3d series, vol. 16, pp. 293–295.

containing Niagara corals. On this there lie seven feet of dark-gray limestones, impure near the base, and for two feet toward the top. Two feet above their bottom is a fossiliferous layer containing *Atrypa reticularis*, a very unusual occurrence in this part of the formation. This limestone is overlaid by a ten-foot bed of cement rock, of which the upper four feet are of poor quality. Next above is a heavy mass of fine-grained, dark-colored, brecciated limestone, filled with a great variety of corals representing the Stromatopora layer of the Tentaculite series. It has here the very remarkable thickness of ten feet with only a few thin beds of typical Tentaculite members above. These are overlaid by the heavily-bedded Pentamerus limestone, which, in the Kingston region, are quite cherty. A slight change in the strike in this vicinity is a notable feature, the relations of which are shown in plate 4. It appears to be connected with the anticlinal shown in section II of this plate. This anticlinal brings up the Tentaculite and cement horizons to the top of the ridge on the line of section II, and they are exposed just north of the road. The synclinal to the east widens to the southward, and holds an area of lower Shaly limestone which passes over the anticlinal and occupies a belt of considerable width in a series of rough ridges lying west of the crest of the main ridge.

Passing along the northern road over the ridge, there are extensive exposures of the upper and lower Shaly limestones with the intervening Becraft limestone, and the overlying Oriskany beds. The Shaly limestones present their usual characteristics of dark-gray, impure, moderately thick-bedded limestones, traversed by pronounced slaty cleavage. The Becraft limestone is in heavy beds, having an aggregate thickness of about thirty feet. The Oriskany consists of gray, very silicious, highly fossiliferous limestone above, with coarse sandstones below. The dips in this region gradually increase in steepness from the anticlinal, westward to eighty degrees in the Oriskany outcrops. The Oriskany beds give rise to a sharply defined subordinate ridge, extending along the slope of the upper Shaly ridge. To the westward there is a wide belt of Esopus shales which outcrop in a series of abrupt ridges of moderate height, but considerable steepness. There are several flexures on this belt, of which the character is shown in section on plate 4.

PLATE 4.



GEOLOGICAL MAP AND SECTIONS OF THE KINGSTON REGION.

Scale, 3,000 feet to one inch.
The vertical scale of the sections is considerably exaggerated.

Returning to the eastern front of the ridge the cement bed is exposed in a series of old quarries, extending for some distance southward. In the slopes above this the Tentaculite bed with its Stromatopora layer is much less conspicuous than to the northward, surmounted by bare cliffs of the Pentamerus limestone.

The relations to the Hudson river shales are exposed at a number of points in the floor of the cement quarries and near the road forks northward. The shales dip steeply to the eastward and have a slightly irregular surface. This relation is not due to faulting but to deposition on a previously upturned and eroded surface, as shown by Davis in an exposure at Rondout.

On the road from East Kingston across the ridge there is a bank of clay and sand at the base, and then continuous exposure of all the members from the cement bed to the Esopus shales. The top of the cement bed is seen at the forks of the short road to the south, with Tentaculite and Pentamerus limestones in the slopes above. The lower Shaly limestone is in the crest of the ridge or constitutes a second crest just west, and is prominently exposed in the road cut. The Becraft limestone is well exposed in a small quarry on the east shore of a pond which lies in a depression in the upper Shaly members. This quarry exhibits twenty feet of light-colored, coarse-grained, massively-bedded, very fossiliferous limestone, but the thickness of the member is somewhat greater, as shown in adjoining surface outcrops. On the west side of the pond the Oriskany formation rises as a small ridge of very sandy beds below and cherty limestones above, containing layers with Oriskany fossils. South of the road this Oriskany ridge coalesces with the main ridge and is separated from the Esopus shales by a hollow which extends for some distance southward. The Esopus shale region westward is a wide belt of high, rough, irregular ridges, which support a scanty vegetation and present an almost continuous outcrop of brownish-gray shales. On fresh fracture these shales are seen to be very dark gray or black, and the original bedding planes are obscured by slaty cleavage which is everywhere pronounced. The formation is traversed by the series of flexures shown in section II, on plate 4, and it is due to these that its area is so wide. The thickness is difficult to ascertain on account of the complexity of structure, but approximately it is not less than 275 feet.

On the east side of the Helderberg ridge, south from East Kingston, there is a continuation of the line of high cliffs of Pentamerus and Tentaculite limestones, which rise from the terrace of clay and sand and trend nearly due north and south. The river has encroached upon the terrace in this vicinity, and a mile south of East Kingston extends to within a few yards of the limestone cliffs which continue near the river bank for some distance. In the brickyards in this region there are a number of exposures in which the clays are seen abutting against the limestones, and in plate 22 one of these is represented. The limestones shown in this plate are the Tentaculite and Pentamerus beds, and their dip is due west at an angle varying from sixty-three degrees to sixty-eight degrees. The overhanging cliffs were of course cut by the Hudson river before the deposition of the clays, and this exposure affords an interesting insight into a detail of the conditions that prevailed in this region in those times. The cement bed is completely buried under the clay from East Kingston southward, excepting at one point a short distance north of the quarry shown on plate 22 where a small stream flows out of the ridge and exposes rock nearly to tide water level. The cement was formerly worked near this outcrop, and the old adit by which it was reached extends under the road just north of the stream. The structure of the ridge in this region is shown in section II on plate 4, and the general relations shown in this section prevail for a considerable distance to the north and south. A short distance south the trend of the ridge changes to south-southwest and the river bank bears off to the eastward. The intervening terrace is an elevated sand plain underlaid by clay, and has a width of nearly a mile at Kingston Point. The lower members in the ridge are deeply buried under the clay and sand, but the upper limestones rise in a cliff or steep slope of considerable prominence. Approach ing Rondout the terrace rapidly decreases in altitude and the eastern base of the ridge is again exposed. This is near the line along which section III of plate is drawn, and this section illustrates the relations of the western edge of the lower terrace on which Rondout is built.

It is in this portion of the ridge that the principal cement quarries of Rondout are situated. They extend continuously along the eastern slopes to the lower loop in the Ulster and Delaware railway, and penetrate far down the dip to the westward. The typical structure in this belt is shown in section IV, plate 4. This gives place northward to an anticlinal, shown in section III. This begins as a sharp, somewhat faulted crumple in the monocline, which rapidly widens and pitches downward to the east and southeast. The cement rock was mined from the east-dipping limb, but as this portion of the mine had long been abandoned and there are no surface outcrops, I could not ascertain the precise relations northeastward. The anticlinal gives rise to a bench along the east side of the ridge, over which the upper road to Kingston passes diagonally. On the crest of this bench the Tentaculite beds are exposed, lying nearly flat, but they dip steeply down its eastern slope and pitch beneath the sand and clay of the terrace. North of the road the bench is terminated by a face in which a gentle arch of the Tentaculite limestone and cement beds are exposed. The cement is being mined from this face in a series of galleries extending to the westward. The west limb of the anticlinal is gently flexed by a low, local synclinal which is irregular in strike and not of great extent southward. The northern road to Kingston crosses the ridge in a partial gap in this vicinity, and the variations in strike are very noticeable in the Pentamerus beds along the road as well as in the cement beds in the mine below.

The formations constituting the ridge in the vicinity of sections III and IV, on plate 4, are the Helderberg limestones, the Oriskany sandstone, the Salina cement series, and the Hudson river sandstones. Mather,* Cook,† Lindsley,‡ Dale § and Davis ‖ have described various features of this portion of the region and their statements are mainly accordant. The fact was recognized that the limestones lie unconformably on the Hudson river sandstones, and this feature is very clearly exposed at a number of

* Loc. cit.

† Geology of New Jersey, 1868, p. 156.

‡ A study of the rocks. Poughkeepsie Soc. Nat. Sci., Proc., vol. 2.

§ The fault at Rondout. Am. Jour. Sci., 3d ser., vol. 18, 1879, pp. 293–295.

‖ Nonconformity at Rondout. Am. Jour. Sci., 3d ser., vol. 26, 1893, pp. 389–395.

points. The Hudson river members are thickly-bedded, dark-gray, very fine-grained sandstones, with occasional thin shale partings between the beds. They dip south-southeast at angles from forty to sixty degrees and extend about half way up the slope of the ridge. Their upper surface is irregular, and Davis has given a figure illustrating an exposure in one of the quarries in which the limestones are seen fitting closely into channels worn along the strike of the sandstones, a relation which precludes the possibility of a fault. He adds: "It is noteworthy that the limestone begins immediately with its fully-determined calcareous character; there is no band of transitional composition; no fragments of the sandstone are contained in the overlying rock. The old, worn surface was swept clean before the corals and crinoids began growing upon it, and their fragments and grindings make the first deposit. Some little pieces of crinoid stems lie directly on the bare sandstones." The limestone lying above this unconformity is the dark-colored massive coralline bed which has long been known to be of Niagara age. Its thickness varies slightly, but averages seven feet. It gives place quite abruptly to the overlying cement series, but with no signs of a break in the sedimentation. The cement series consists of an upper and lower cement bed separated by a few beds of limestone. The thicknesses vary somewhat. The lower cement bed attains a thickness of twenty-two feet, which continues for some distance in the vicinity of section IV. The overlying limestones are here about three feet thick, and the upper cement bed five feet. Farther northward the lower cement bed thins and the intervening limestones and upper cement bed thicken considerably. The course of the cement series down the dip westward is shown by the broken lines C — C on the section in plate 4. Overlying the upper cement bed there are several thin beds of impure limestones containing *Leperditia alta* and, at their surface, prismatic mud cracks, as noted by Lindsley. The Tentaculite limestones have a thickness of about twenty-five feet, of which the upper six feet are classed as the ribbon limestone by Lindsley and contain *Stromatopora*. The Pentamerus limestone constitutes the crest of the ridge, and outcrops in cliffs of light-gray color. It presents its usual character of a lead-gray massive limestone, and carries a considerable amount of chert in courses and dissemi-

PLATE 5.

QUARRY IN BECRAFT LIMESTONE, KINGSTON, N. Y. LOOKING NORTH.

nated lenses. It contains *Pentamerus galeatus* and crinoidal fragments. Its thickness was not determined, but it is fully thirty feet as stated by Davis. The lower Shaly limestone extends along the center of the ridge with a thickness of about sixty feet, and the Becraft limestone lies high up on the western slope. Both dip steeply to the west. There are lime quarries in the Becraft beds which expose a thickness of about thirty-five feet of the usual heavily-bedded, light-colored, highly fossiliferous limestone, containg abundant calcite replacements of crinoid cups. One of these quarries, lying north of the road from Kingston to Kingston Point, is shown in plate 5. The upper Shaly limestones extend down the western slope of the ridge. The full thickness of the formation is well exposed near the end of the northern loop of the railroad, where the ridge widens somewhat, and here also there are excellent outcrops of Oriskany beds, which are more widely eroded southward. The upper Shaly beds have a thickness of about 125 feet. They are similar to the lower Shaly beds, and consist of brownish-gray impure limestones traversed by slaty cleavage. They are, as usual, sparingly fossiliferous, containing *Leptæna rhomboidalis*, *Stropheodonta radiata*, *Spirifer macropleura*, *Spirifer perlamellosus*, *Orthis oblata*, and others. The Oriskany formation is here extensively developed, and it contains a bed of conglomerate which, as stated by Davis, extends over a considerable area about Rondout. This bed consists of small pebbles, up to a quarter or a third of an inch in diameter, in a slightly calcareous sandy matrix. The pebbles vary from rounded to subangular and consist mainly of white quartz. It attains a thickness of nine feet at several points but is not continuous throughout. Its greatest development is just north of Wilbur in a steep hill slope near the bank of Rondout creek, but it is well characterized in the outcrop near the northern end of loop of the Ulster and Delaware railway. The upper beds of the formation are dark, hard, calcareous sandstones, with some cherty bands, which weather to a dull snuff-brown and exhibit abundant casts of many typical Oriskany fossils. The total thickness of the members in this locality is about thirty feet, which is a most unusual thickness for the formation. To the west of the Oriskany belt there are high ridges of Esopus shales—Cauda-galli grit.

South of the line of section IV (plate 4) the dips gradually decrease to fifty degrees. In about half a mile the ridge narrows and ends, and to the southward for some distance there are low lands and sand-covered slopes, in greater part occupied by the buildings of Rondout, an area in which there are no exposures. In the interval to Rondout creek there are several outcrops of Hudson river sandstone along the slopes just south of the main street, and a small showing of the upper and lower Shaly beds and intervening Becraft limestone, a short way beyond. These members and the underlying limestones and cement beds cross the Rondout creek half a mile northeast of the West Shore railway bridge and rise high in the bank on the south side of the creek. The Oriskany beds do not cross the creek but extend along the west bank on a long slope surmounted by Esopus shales. The conglomerate before described is a conspicuous feature of this exposure, and its area is extended somewhat by a small synclinal extending along the base of the slope. To the south the Oriskany beds pitch downward somewhat, and the overlying Esopus shales constitute the high bank for a short distance. They lie in a broad, gentle synclinal which pitches gently to the northward.

Approaching the railroad bridge a series of flexures come in which carry the Oriskany and Esopus beds westward and bring up the underlying limestones. They are finely exposed under the bridge and to Wilbur, in cliffs rising high on both sides of the creek. The relations at this point are shown in the following section taken from Davis's paper.

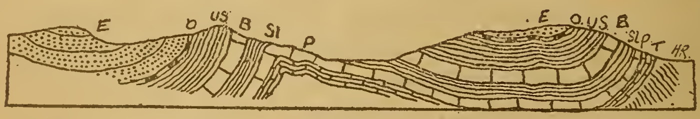


FIG. 4.—Cross section of Rondout Creek valley, just north of Wilbur, N. Y., after Davis. Looking north. E., Esopus shale; O., Oriskany sandstone; US., Upper Shaly limestone; B., Becraft limestone; Sl., Lower Shaly limestone; P., Pentamerus limestone; T., Tentaculite and cement beds; HR., Hudson formation.

The lower Shaly and Pentamerus beds are the most conspicuous features in these exposures, and they are finely exhibited. The Becraft beds are high in the adjoining slopes, where they have been extensively quarried for lime burning. In plate 6

PLATE 6.

HELDERBERG LIMESTONES ON NORTH BANK OF RONDOUT CREEK, AT WILBUR, N. Y. LOOKING NORTH.

there is shown a portion of the exposures along the Rondout creek at Wilbur.

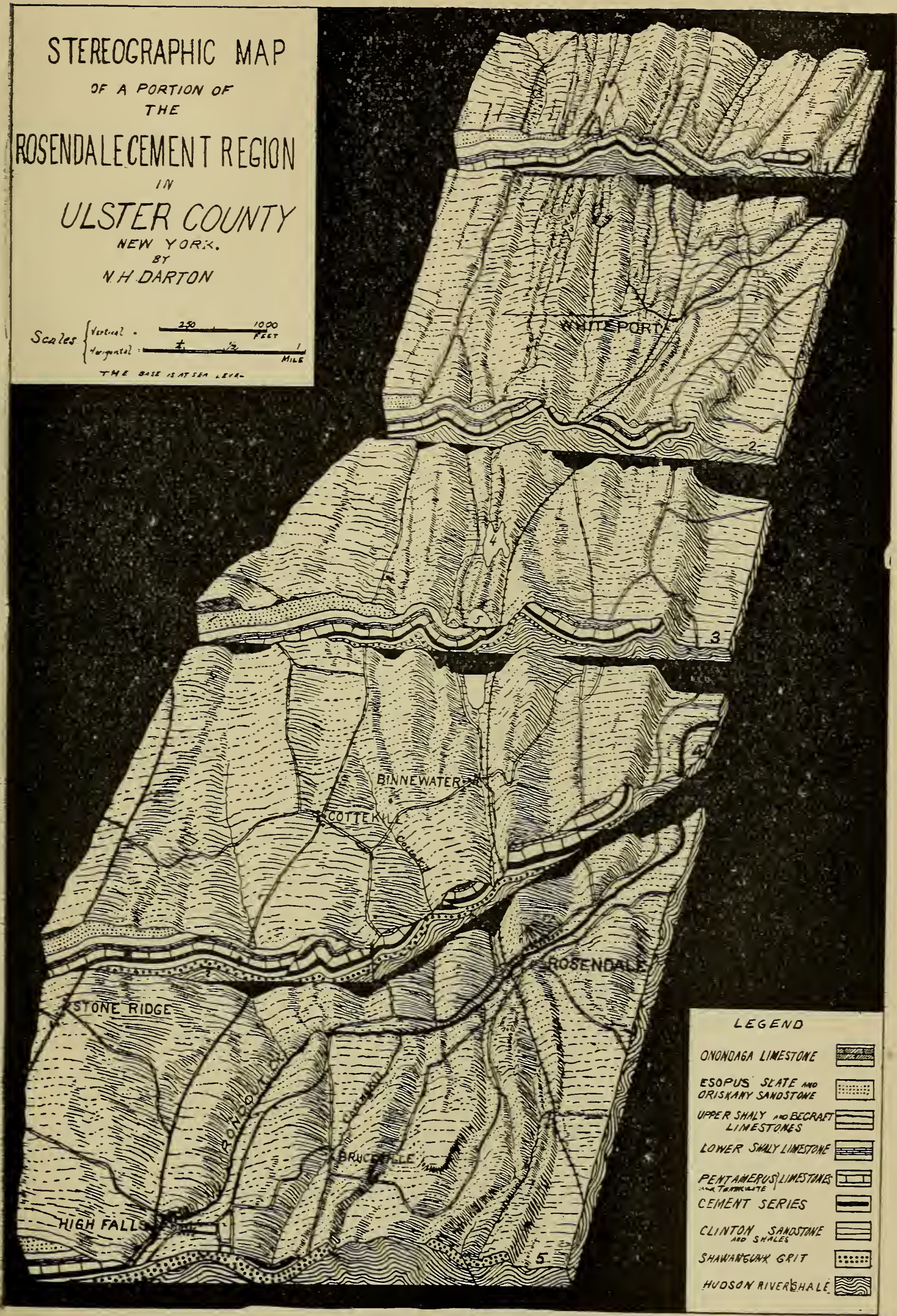
These flexures pitch gently downward to the north and pass into the elevated region occupied by a broad belt of Esopus shales, overlaid by Onondaga limestones to the northwest. To the southward the flexures are in the Hudson river shales under the low region south of Wilbur, and the limestones extend southwestward in a monoclinal ridge of which the relations are shown on the left of section V, plate 4.

Opposite Wilbur there is the basin-like area of which a cross section is given on the right of section V. I did not make an extended examination of this feature, for it appears to have been carefully explored by Prof. Davis. It is an extension of the synclinal which crosses Rondout creek just north of the railway, and it terminates in about a mile in a "spooning up" of the dips. The area includes the cement series, Helderberg limestones, Oriskany sandstone, and a small mass of Esopus shales. The West Shore railway crosses its center and affords excellent exposures of most of the beds. There are also a number of quarries exposing the Becraft limestone and cement series. The cement bed is much thinner in this region than it is to the northward, and undoubtedly merges into the thin-bedded waterlimes as suggested by Davis. The Niagara was not observed south of the Rondout quarries. West from Wilbur along road and railroad there is a section across the monoclinal belt, from lower Shaly limestone to Onondaga limestone. The dips are steep although somewhat variable, but in the upper beds of the Esopus shales they flatten to ten degrees and the overlying Onondaga limestones lie in a very shallow synclinal. The Esopus and Onondaga beds are very finely exposed in the railroad cuts and the intergrading of materials is clearly exhibited. The black, slaty Esopus shales gradually merge into impure limestones of dirty buff color, and these grade rapidly into the light blue-gray, cherty Onondaga limestones. The slaty cleavage extends for some distance into the transition beds, but gradually gives place to the massive bedding of the pure limestones. In the hollow just west of these cuts the Esopus shales extend some distance north where they pass under an arch of the limestone. From this region to the west, north and the northeast there is an extended series of shallow synclinals and low anticlinals n which the Onondaga limestones and Esopus shales are extended over a wide area. The general structure of this region is represented in sections II, III and IV, plate 4. The city of Kingston, excepting the Rondout portion, is in greater part built on the Onondaga limestone or on the sand by which this formation is deeply covered to the southwest. South of the Ulster and Delaware railroad there is a general pitch to the north, and the Esopus shales extend in long fingers northward along the anticlinals. These fingers unite around the ends of synclinals of the limestone southward, and the formation covers a wide area in the southwestern outskirts of the city and thence extends southward to the end of the great anticlinal of the Binnewater region. The Onondaga limestone area attains its greatest width near the line of section III, where it is not less than three miles wide from east to west. In this extension it occupies seven flexures, of which the westernmost are very broad and low, and pitch northward. They die out in the vicinity of Esopus creek, west of Kingston, for in the overlying Hamilton shales westward their only apparent influence is to change the direction of the general west-northwest monocline to north and north-northwest for a short distance. The pitch of the flexures in the northeastern section of the city is to the south, as shown in section II, and in these the limestone soon terminates in a series of fingers. Thence northward the principal flexures are in a broad belt of Esopus shales which is bordered westward by a west-dipping monocline of Onondaga limestone occupying a much narrower belt. This monocline is somewhat flexed locally and presents many minor, local variations in dip.

The most prominent flexure in the Kingston region is an anticlinal which begins near the West Shore railroad north of Wilbur and passes under the City Hall and along Clifton avenue by the almshouse. It is in Onondaga limestone from just south of Union avenue to near the almshouse, but is marked by long fingers of Esopus shales beyond, and at one point on the hilltop half a mile northeast of the City Hall this formation is exposed in a very small inlying area along the top of the arch.

Exposures of Onondaga limestone are frequent about Kingston, but they all lie to the southwest, south and east of the railway station, as the northwestern part of the city is heavily

PLATE 7.


STEREOGRAPHIC MAP
OF A PORTION OF
THE
ROSENDALE CEMENT REGION
IN
ULSTER COUNTY
NEW YORK.
BY
N. H. DARTON
Scales Vertical 250 1000 FEET
Horizontal ¼ ½ 1 MILE
THE BASE IS AT SEA LEVEL
WHITEPORT
BINNEWATER
COTTEKILL
ROSENDALE
STONE RIDGE
RONDOUT
BRUCEVILLE
HIGH FALLS
LEGEND
ONONDAGA LIMESTONE
ESOPUS SLATE AND ORISKANY SANDSTONE
UPPER SHALY AND BECRAFT LIMESTONES
LOWER SHALY LIMESTONE
PENTAMERUS LIMESTONES AND TENTACULITE
CEMENT SERIES
CLINTON SANDSTONE AND SHALES
SHAWANGUNK GRIT
HUDSON RIVER SHALE

covered by a Champlain sand plain. Their location and the structural features which they present are shown by the dip marks on the map and by the sections. There are many exposures in the eastern part of the city, and in those near the Ulster and Delaware railway, east of the station, an irregular synclinal is seen, which extends across the principal axes of the north and south flexure. The dips are very variable along this belt and the beds are considerably broken. There are many veins of calcite in the fractured portions which give a rather unusual checkered aspect to the limestone.

Southwest of Kingston, up the Esopus valley, there extends a wide belt of Onondaga limestone. It is traversed by gentle flexures which extend from the southward and gradually die out north of Esopus creek. On the anticlinals the Esopus shales extend northward in fringes, and there are corresponding southward extensions of the limestone in the adjoining synclinals. The most prominent of these flexures are about Hurley. On the west side of the Esopus creek there rise steep slopes of Hamilton shales surmounted by terraces of the flagstone series. The slope is steep and continues for a long distance, but it is broken down for an interval west of Kingston. The beds are dark shales with intercalated thin sandy beds. There are many exposures north and west of Kingston in slopes and along creeks.

Southeast from Wilbur the monoclinal ridge continues for some distance along the north side of Rondout creek, presenting the general features shown on the left of section V, plate 4. The synclinal and anticlinal of Esopus shale west of this ridge pitch up to the southward, and, finally, the underlying formations are brought up in succession to the surface. These are, however, soon cut off to the westward by Esopus shales brought up by a fault which begins on the arch of the anticlinal and gradually crosses the ridge to the southward. The structure of this district was determined by Prof. W. M. Davis, and in the following figure a portion of his map is reproduced, which I believe fully illustrates the relations. I have introduced on this map a portion of the northeastern flank of the Rosendale-Whiteport anticlinal which was not shown on the original. The structure of the south end of the ridge is also shown in the first section on plate 7.

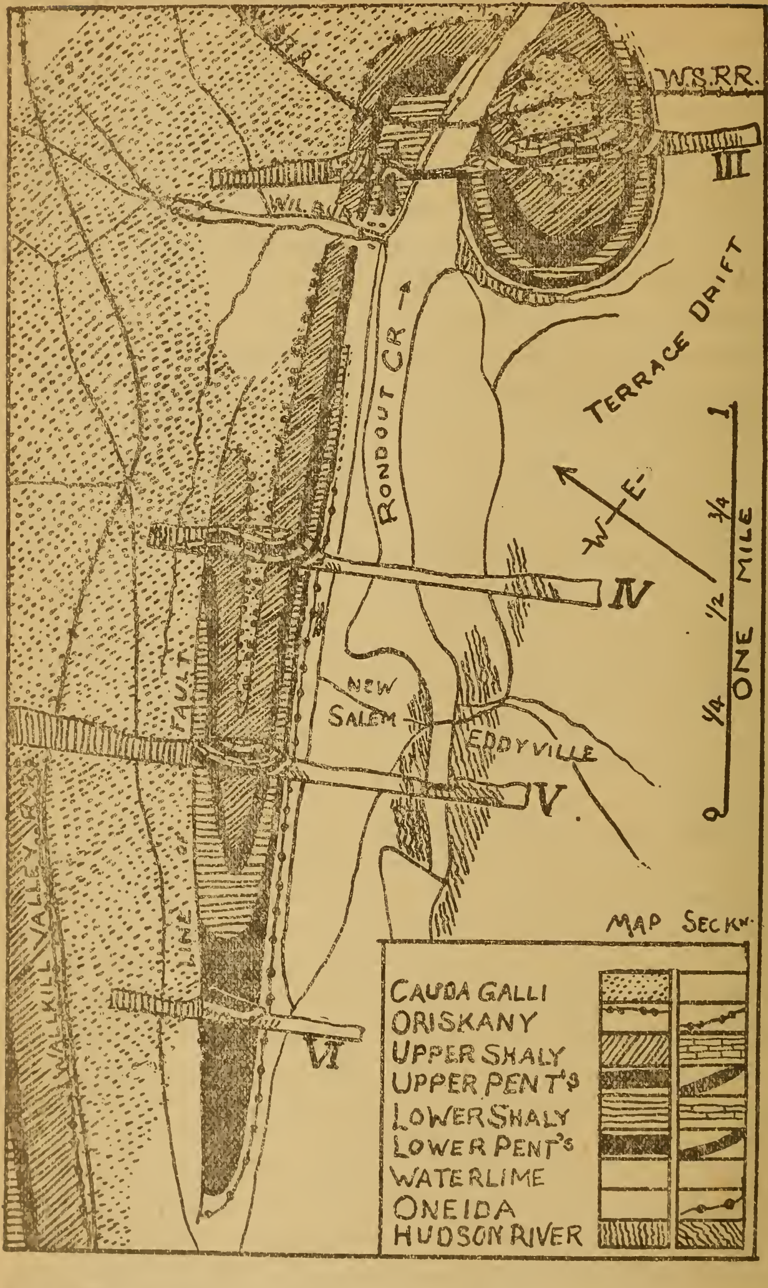


FIG. 5.—Map and sections of the southern part of the Kingston region, by W. M. Davis. Enlarged.

The eastern front of the ridge consists of cliffs of Pentamerus limestone, surmounting steep slopes in which the underlying formations are occasionally seen. The cement series is exposed at several points, but it consists almost wholly of the waterlime beds which contain occasional thin lenses of cement rock. The cement series is underlaid by quartzites which begin half a mile south of Wilbur and gradually thicken to eighteen feet in a couple of miles. Davis suggested that they are the Oneida or Shawangunk grit, but, as I have shown above, they are somewhat younger. Along the lower slopes there are occasional showings of Hudson river rocks, notably at a point behind New Salem, to which Davis refers and which is shown in his map. Here they are seen overlaid by the quartzite and waterlime beds, and there is but little of the discordance in dips so conspicuous to the northward. There is some difference in the amounts, however, and this relation is, I take it, only a near coincidence of altitudes and not due to a less degree of unconformity.

The ridge ends a mile and a half south of Eddyville in a cliff of Pentamerus limestone facing to the south. Its termination is due to the fault which for some distance to the southward brings the Esopus shales against the Hudson river shales.

Rosendale–Whiteport Cement Region.

The principal structural features of this region are shown in the stereogramic map and sections, plate 7, and the areal distribution of the formations is represented on the geologic map. There are two principal flexures comprising a great anticlinal extending through the center of the region, and a synclinal to the eastward; they carry subordinate flexures of varying degrees of magnitude and continuity. These flexures contain the cement beds, which come in again about Rosendale and Whiteport as rapidly as they thinned out about Rondout, and here attain their maximum development. As no determination has ever been made of the structure of this region, considerable time was devoted to its study, particularly of the cement beds, and many interesting structural and stratigraphic features were discovered.

The synclinal begins in the Kingston region and holds Esopus shales to just east of Whiteport station, beyond which the northerly pitch brings up the underlying formations in succession along its axis. The beds in the synclinal are cut off to the eastward by the fault described above. This fault gradually decreases in throw southward, and passing out of the Esopus shales cuts off the Oriskany sandstone and Helderberg limestones in succession along the eastern limb of the synclinal, finally dying out at a point due west of Creek Locks. Near its termination the Clinton quartzite appears to come in on the uplifted block, and the dislocation is between this member and the cement series which pitches up from below the Tentaculite beds west of the fault. The fault is covered by sand for a considerable distance in this vicinity, but there is an exposure, apparently, of its termination, in an old quarry in which the cement beds are seen slipped against a slickensided, vertical face of the quartzite. Near the surface the bedding of both is conformable, but below, the cement series dips steeply westward.

As the cement series comes to the surface it is seen to contain thick cement beds, and these have been worked all along the eastern side of the ridge to which the synclinal gives rise. The general structure of the synclinal in the vicinity of these workings is shown in the second and third sections on plate 7. The dips are from fifty degrees to sixty degrees along the eastern crest of the ridge, but they decrease westward and become flat for some distance, then very gently anticlinal. The road along the top of the ridge passes along flat beds of Pentamerus limestones, which are spread out over a considerable width by this structure. In the center of the ridge the dip increases, and the synclinal holds a wide area of lower Shaly limestone which extends nearly to Rosendale. At their southern terminus they finely exhibit the synclinal structure of the beds. The principal cement bed has a thickness averaging about twenty feet along the eastern slopes of the ridge, and it has been mined very extensively. It is massively bedded and uniform in composition, with only occasional thin cherty streaks. It lies on the Clinton quartzite, and the relations of this formation and the underlying red shales are very clearly exposed in the adit to the New York Cement Company's quarry. Here the quartzite is twenty-two feet thick, and it consists of regular beds three to twelve inches in thickness, in greater part welded together. Their color is light-gray with buff-brown streaks, and many of the beds have a characteristic minute cross-bedding within themselves brought out by the slight differences in tint. The overlying cement is perfectly conformable and in greater part welded to the quartzite, but it is strongly contrasted by the great dissimilarity in materials, there being no transition beds and no intervening Niagara limestone. The shales underlying the quartzite are in greater part dull red in color, moderately fined grained, massively bedded as a whole, but breaking into shale on exposure and having a thickness of twenty-five feet. One or two beds are a dirty buff-tint in part, and at the top are two inches of gray shale which gives place abruptly to the quartzite. There appears to have been some slight slipping along this bed. About four inches from the top of the shale series here is a two-inch layer of breccia of small angular masses of cement-like materials in a gray-sand matrix. The lower part of the shales merge into two to three feet of dull gray-green grits, with blotches of pyrite and some small quartz pebbles, which lie on the Hudson river shales and undoubtedly represent the beginning of the Oneida or Shawangunk grit sediments. The dips at this opening are fifty degrees, and they decrease to forty-five degrees in the several quarries to the southward.

Rondout creek crosses the synclinal just below Rosendale, but does not appear to cut through to the cement near the axis of the flexure. At the point where the cement is crossed there are no outcrops, and for some distance to the southward the rocks are covered by sand. On the north bank of the creek there are cliffs of Pentamerus limestone in which the beds lie almost flat, and the formation extends up the slope southward on a gentle pitch to the north, which rapidly increases in amount to twenty degrees and twenty-five degrees. A short distance south of the river the synclinal "spoons out," the Pentamerus beds end in a line of low cliffs, and the cement beds outcrop at their base and circle around to the west and northwest. In section IV on plate 7, and in figure 11, there are shown the relations in the synclinal near its southern termination.

The cement has been quarried to some extent around the southern rim of the synclinal, and its relations are clearly exposed in these quarries, but elsewhere there is a heavy mantle of sand. The principal cement bed has a thickness of twenty feet and lies directly on Clinton quartzites. Near the entrance to the principal quarry the Shawangunk grit is exposed. Here it has attained a thickness of fifteen feet, is massively bedded, and its color has become white.

South from this region the western portion of this synclinal is continued in the Shawangunk grit, and in a local widening and deepening of the flexure, a mile and a half south of Rosendale, there is a small outlier of the cement bed obscurely exposed at several points. It crosses the railroad and extends around the end of a small local anticlinal which pitches up rapidly to the southward.

At Rosendale the western limb of the synclinal is traversed by a longitudinal fault which has offset the cement and associated beds to a considerable degree.

This fault crosses Rondout creek near the center of the village and extends up a depression to the northward, dying out in about a mile. Its presence is marked by a low cliff of Pentamerus beds along the canal and the juxtaposition of the upper part of the lower Shaly beds and the Pentamerus limestone a short distance north. To the south it passes into the Shawangunk grit area, where it was traced for some distance. Its maximum displacement is near Rosendale, where the amount is about 200 feet. Its general relations are shown in section IV, plate 7, and in figure 6. Some details of this overthrust are finely exposed in an abandoned quarry on the slope just south of the creek, opposite Rosendale, and it is on this exposure that the following sections are based.

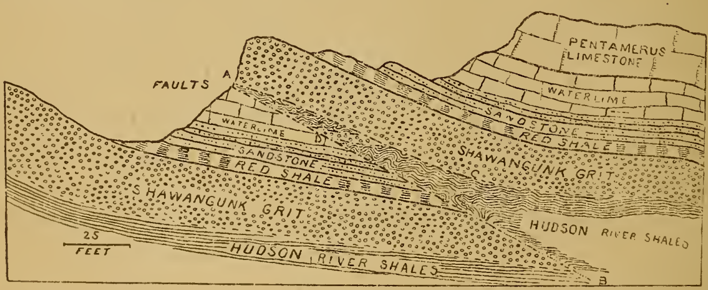


FIG. 6.— Cross section just south of Rosendale showing relations of overthrust fault. Looking north-northeast.

The wedge of cement has been worked out for a length of 200 feet, and the fault plane is the hanging wall of the quarry. Many minor details of the slate wedges and crumplings are not represented in the figure, but there is shown at D a small wedge of grit which is faulted into the main slate wedge at one point. The principal fault plane is along A–B, but there has also been considerable movement along A–C and in some of the beds above, which have slickensided the surface of the grit. The various small cross-faults and minor crumplings are irregularly intermingled in the displacement, and I did not attempt to work them out. The relations below the cement wedge are not fully exposed, but there are many scattered outcrops in the vicinity which exhibit the beds and their dips. This fault is probably the one referred to by Cook in his "Geology of New Jersey,"* as a local inversion of the fold which has overturned the grit on to the cement. South from this point for some distance there are no outcrops exhibiting the relations of this fault, owing to the heavy sand cover. It crosses the railroad about a mile to the southward, and beyond this point its relations are clearly exposed in continuous outcrops of Shawangunk grit. It gives rise to a sharp cliff, which is conspicuous for about a mile and a half, and finally dies out, apparently with the termination of the fault. Its relations in this region are shown in the last section on plate 7 and sections I and II of plate 12. Owing to this fault the cement beds cross Rondout creek at Rosendale in two narrow belts. They are very near together and separated by small tongues of lower Tentaculite beds which are not clearly exposed. The easternmost cement belt pitches down to the northeast and is cut off by the Tentaculite and Pentamerus limestones along the west side of the fault. The western belt rises gradually to the northward along a northeast dip and extends continuously nearly to Whiteport on the east side of the valley, which is excavated along the arch of the Rosendale-Whiteport anticlinal. The eastern limb of this anticlinal is the western limb of the synclinal described in the preceding pages, and its relations are shown in the first, second, third and fourth sections on plate 7 and in figures 7 and 8.

The cement mines at Rosendale extend down the east slope of the beds and to the northward along the strike. The galleries

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* 1868, pages 156–157.

begin at the western outcrop but there is also an outlet to the mines in an inclined adit which comes out in the depression just west of the fault. A portion of the western entrance to the galleries is shown in plate 8, and this plate also illustrates the relations of the two cement beds.

There are two cement beds in the Rosendale-Whiteport region, and at Rosendale the lower bed or "dark cement" averages about twenty-one feet in thickness, and the upper bed, or "light cement," eleven feet, with fourteen to fifteen feet of waterlimestones intervening. The lower bed lies directly on the Clinton quartzite, the even upper surface of which affords an admirable floor for the galleries. For about eighteen inches at the bottom the dark cement is too sandy for use. With this exception and a few small layers of chert it is all available.

Overlying the cement beds there are several feet of waterlime beds containing thin cement layers. The Tentaculite and Pentamerus beds next above present their usual characters but are somewhat increased in thickness, and at Rosendale they give rise to a very high ridge presenting precipices to the south and west, as shown in and near the fourth section on plate 7. This ridge extends northward along the east side of the valley which occupies the crest of the anticlinal, and there is an almost continuous succession of cement quarries along its western face. The formations dip gently eastward along this belt and have a very slight upward pitch to the north, which rapidly increases in amount near Binnewater station. The lower part of the valley is excavated through the Clinton quartzite and red shales to the surface of the Shawangunk grit, but farther northward it is in the Clinton quartzite. The cement beds also extend along the west side of the valley, and dip gently to the westward on the western limb of the anticlinal, where they are worked at several points. They are overlaid by Tentaculite and Pentamerus limestones, which constitute the slope westward.

North of Binnewater station the axis of the anticlinal pitches up and the cement beds and overlying limestones are carried to a considerable altitude above the valley, as shown in section III

PLATE 8.

SOUTHWESTERN ENTRANCE TO CEMENT QUARRY AT ROSENDALE, N. Y.

on plate 7. The valley is cut laterally on the western slope of the flexure in this vicinity and exposes the Clinton members and the Shawangunk grit in a small inclosed area. The principal cement openings are high up on the slope, but the beds are also reached by an adit to which they descend on a steep easterly dip. This adit begins in west dipping Shawangunk grits, crosses a small anticlinal of the underlying Hudson river shales, greatly contorted, and then penetrates the east dipping Shawangunk grit, and the Medina shales and Clinton quartzites to the cement. The cement rock on the western limb of the anticlinal outcrops along the center of the valley, and there are several openings along its course near the shore of the fifth Binnewater, west of the railroad. On the railroad in this vicinity there are extensive exposures of the Clinton and Medina members, notably in "Red rock cut," which is in the red shales. The first cuts expose the lower cement bed lying on twenty feet of Clinton quartzite. The dip is fifty degrees to the west-northwest. The quartzite is light colored, thin bedded and has the cross bedding by which it is characterized in the cement openings on the east side of the synclinal as described on a previous page. The underlying shale series has a thickness of about twenty feet and consists of hard, massively-bedded, fine-grained, rather bright brown-red rocks, which break up into shale on weathering. The Shawangunk grit is a light-colored, quartzitic, massively-bedded quartz conglomerate, having a thickness of fifty feet in the adits to the cement mine, but it thins rapidly northward. In a short distance beyond "Red rock cut" the pitch of the anticlinal changes to northward, and the Shawangunk grit, red shales and quartzite are carried below the surface in succession. This is due to a small synclinal which crosses the principal flexure diagonally on a nearly due north and south trend. This small synclinal dies out a short distance south, but it widens and deepens northward and extends to beyond Hurley, where it is in the Onondaga limestone. The cement beds are extended over a superficial area of some width along this synclinal, and they have been widely removed from it along the railroad which crosses the ridge in a gap in this vicinity. In the following figure the relations of this synclinal are shown.

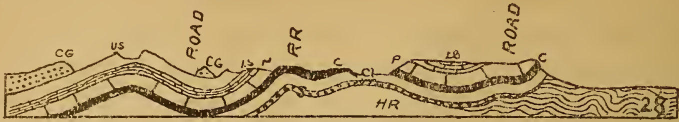


Fig. 7.—Cross section at the north end of the fifth Binnewater. Looking north. CG., Esopus shales; US., Upper Shaly and Becraft limestones; LS., Lower Shaly limestone; P., Pentamerus and Tentaculite limestones; C., Cement series; Cl., Clinton and Medina members; S., Shawangunk grit; HR., Hudson river shales.

Along the center of this basin, just north of the line of figure 7, there is a small tongue of Pentamerus limestone which extends from the northward across the railroad for a few yards at the south end of the fourth Binnewater. Along the shore of this Binnewater the Tentaculite and Pentamerus limestones arch over the cement on the anticlinal and dip west beneath the lower Shaly limestone.

To the north of this cross synclinal the eastern portion of the anticlinal pitches up again and brings to the surface of the valley, the Clinton and the Medina members, the attenuated Shawangunk grit, and a considerable area of Hudson river shales.

The cement beds have been worked all around the sides of this area and for a greater or less distance down the west dip. They are surrounded by the Tentaculite and Pentamerus limestones, except to the south along the axis of the anticlinal, where the valley is cut down to the cement series. In the following figure there is given a cross-section near the center of this district which illustrates the principal features. Further data in the portion somewhat north of this section are shown in the second section in plate 7.

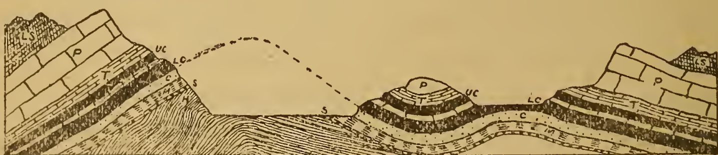
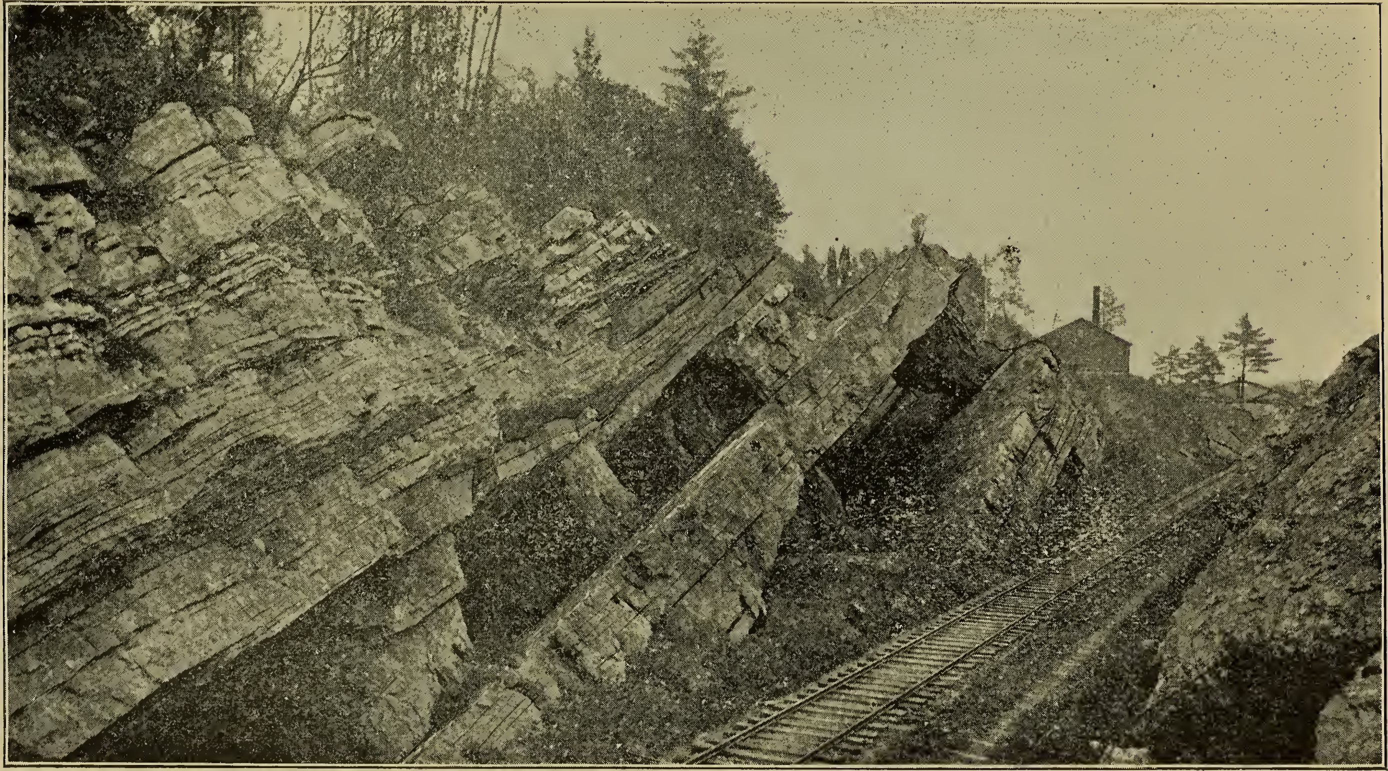


Fig. 8—Cross-section of the cement district one mile south of Whiteport station. Looking north. LS., Lower Shaly limestone; P, Pentamerus limestone; T., Tentaculite beds; UC., Upper Cement beds; LC., Lower Cement beds; C., Clinton quartzite; M., Medina shales; S., Shawangunk grit, and H., Hudson river shales.

The pitch of the fold is mainly in its western limb in this vicinity and the cement beds on the western side of the valley

PLATE 9.



CEMENT BEDS IN QUARRIES ONE MILE SOUTHWEST OF WHITEPORT STATION, N. Y. LOOKING NORTH.

are carried high up the slope of the ridge, where they finally attain a dip of sixty degrees to the westward as shown in the second section in plate 7. A short distance north of this section they pitch down again and are overarched by the Pentamerus and Tentaculite limestones along the eastern slope of the ridge. On the eastern limb of the main arch there develops in this district a gentle synclinal and anticlinal, which greatly widen the superficial area of the cement beds in the valley. They are shown to the right in figure 8. They do not extend far to the southward, but they extend north through the upper Binnewater district. They are well exhibited in the cement quarries and mines along the turnpike, south of Whiteport Station. The dips are not over five degrees at greatest on these flexures, and for the most part they are less than five degrees. North of the line of the second section (on plate 7) the cement beds in this shallow flexure gradually pitch beneath the Tentaculite and Pentamerus beds which occupy a wide region of low rocky ridges west of Whiteport.

In the cement region south of Whiteport there are the two cement beds, the upper or "white cement" having a thickness of twelve feet and the lower or "gray cement" eighteen feet, with seventeen to twenty feet of waterlime beds between them. The underlying formation is the Clinton quartzite, and this in turn is underlaid by the red shales, which in the northern part of the region are of a somewhat diminished thickness. The quartzite is in moderately thin beds of flesh-buff and pink colors of rather bright tints which are largely in ribbonings or mark a minute cross sub-bedding. The Shawangunk grit has a thickness of only three feet in the central part of the area and is a dirty brown to gray, pebbly quartzite. The best exposure of the formations underlying the cement series, and the only complete one, is along the railroad south of the southernmost turnpike crossing. A portion of this is shown in plate 9, which clearly illustrates the relations of the two cement beds.

In this plate the location of the Clinton shales is in the depression down the bank from the small boiler-house, the Shawangunk grit exposure is just to the right of this, near the railroad tracks, and the Hudson river shales are under the bridge. To the right of the eastern abutment of this bridge there is a wide valley occupied mainly by Hudson river shales and the Clinton members but in which there are no outcrops.

About Whiteport station and northward, the Rosendale-Whiteport anticline bears upon its flanks a series of flexures of various sizes, the relations of which are represented in the following figure.

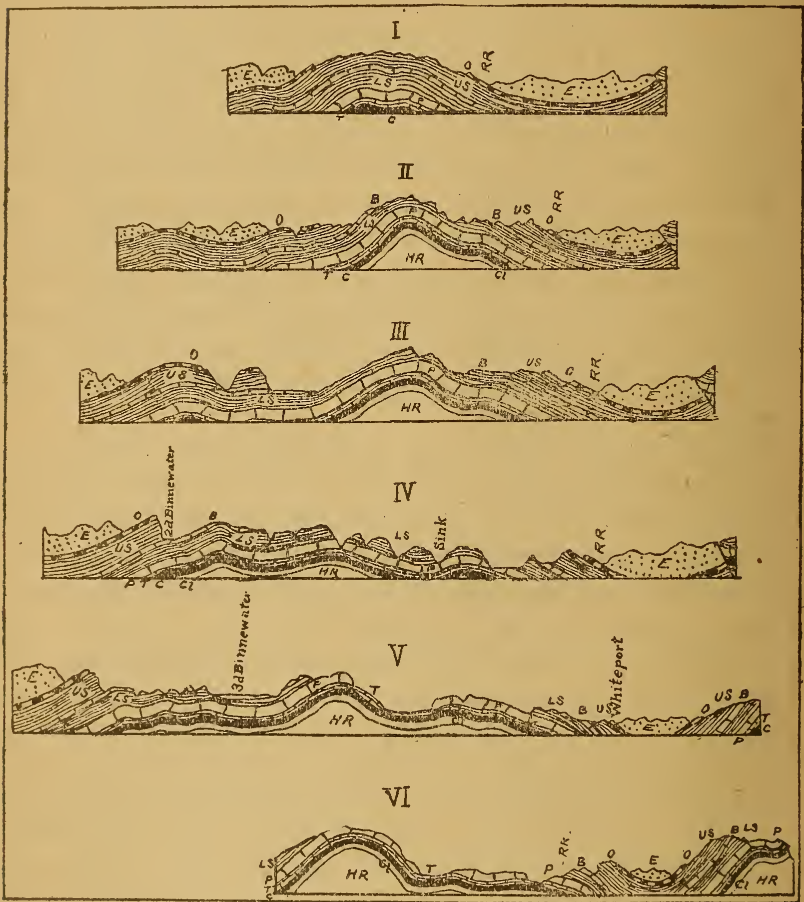


FIG. 9.—Cross-sections of region about Whiteport station and the Upper Binnewaters. Looking north. E., Esopus shales; O., Oriskany sandstone; US., Upper Shaly limestone; B., Becraft limestone; LS., Lower Shaly limestone; P., Pentamerus limestone; T., Tentaculite limestone; C., Cement series; Cl., Clinton formation; HR., Hudson river shales. Vertical scale considerably exaggerated.

It may be seen from the botton section in this figure that the cement beds are brought near to the surface over a considerable area in this region, and there are several small openings down to it. The pitch of the anticlinal is to the north and this finally carries the Helderberg limestone and Oriskany beds beneath the Esopus shales in the wide area of that formation south of Kingston. The region has been deeply eroded and it consists of a series of very sharp, rough, rocky ridges, due mainly to the wide extension of the upper and lower Shaly limestones The upper Binnewaters, numbers 1, 2 and 3, lie in the valleys between the ridges northwest of Whiteport station, and there are several meadows, but the depressions are mainly deep, narrow, rocky gorges. The greater number of the ridges are not high, but their precipitous sides and the scrubby growth which they bear gives to the region a peculiarly wild aspect. This roughness is by no means fully expressed in the stereograph (plate 7), which represents only the larger features. The principal ridge is along the highest arch of the anticlinal, but it is cut across diagonally by a valley near the center of the region, as shown in figure 9. The Binnewaters are beautiful little lakes nestled among the ridges in a most picturesque manner. They are more or less completely surrounded by cliffs or rocky slopes and have considerable irregularity in outline. The first or northernmost Binnewater is the largest and the second and third empty into it by separate outlets from the south. The second Binnewater is a very small body of water lying in a narrow gorge between the upper Shaly and Becraft limestones. At its head there is a meadow of some size and a small meandering stream which heads far northwest of the first Binnewater. This stream flows south between ridges of Esopus shales and the Oriskany sandstone and turning abruptly to the east passes through a small gorge in the Oriskany and upper Shaly limestone, beyond which it meanders northward through a meadow into the second Binnewater. The third Binnewater is in a valley which heads in a complex series of Shaly limestone hills to the southward, and it is some distance south of the second Binnewater. Its valley is separated from that of the second Binnewater by a long, narrow ridge of Becraft and lower Shaly limestones which ends in a point at the first Binnewater. The valley of the first Binnewater is in Esopus shales to the northward, and it extends along the western flank of the central axis of the anticlinal. In its course southward it cuts through a small arch of Oriskany beds in a short gorge, then flows through a region of upper Shaly limestone. At the head of the Binnewater there is a meadow underlaid by Becraft limestone and the lake basin is in the lower Shaly beds. The outlet is southward through a narrow gorge extending diagonally across the central anticlinal of the region, below which the brook turns eastward around a cliff of Pentamerus limestone and flows into a sink. Its waters come out again in a spring on the opposite side of a lower Shaly limestone ridge and flow past Whiteport station to the Rondout Creek.

The exposures in the upper Binnewater region are very numerous. The Oriskany beds are extensively developed as silicious and somewhat cherty limestones containing an abundant fauna. They extend along the Wallkill Valley railroad north from Whiteport station for several miles, and there are many excellent exposures of fossiliferous members in the slope on the west side of the track. The upper Shaly limestone constitutes many of the ridges south and west of the upper Binnewaters and a large portion of the slopes between the railroad and the road to Hurley, north of Whiteport station. It is a moderately dark-gray impure limestone, with the characteristic slaty cleavage which gives rise to very sharp ragged outcrops. It is moderately fossiliferous, and its thickness is about 100 feet. The Becraft limestone occupies several ridges south of the second Binnewater, the ridge between the second and third Binnewaters, the western and northern shores of the first Binnewater, and a portion of the cliffs and slopes of the high ridge northeast of the first Binnewater. It crosses the road to Hurley a mile northwest of Whiteport station, and extends along the second ridge west of the railroad to within a few yards of the station. It is the usual light-colored, thick-bedded, very fossiliferous limestone and has a thickness of thirty feet.

The lower Shaly limestone forms the central ridges of the upper Binnewater region and gives rise to the greater portion of the high ridge east of the first Binnewater. It is closely similar to the upper Shaly limestone but is not over sixty feet in thickness. The Pentamerus limestone occupies an area of considerable extent west of Whiteport, where it outcrops in low cliffs. It rises high in the ridge east of the third Binnewater and presents an escarpment to the eastward, as shown in the lower section in figure 9. In the valley at the foot of this escarpment the Tentaculite beds are brought up by an anticlinal over a small inclosed area and some pits have been sunk through their lower beds to the cement rock. This anticlinal extends into the eastern slope of the ridge southward, and this slope consists of an east-dipping mass of Pentamerus limestone to the line of the second section in plate 7, where the cement rock comes to the surface.

The Oriskany, upper Shaly, Becraft and lower Shaly beds cross the railroad just south of Whiteport station and extend to the southwest in the synclinal already described. The beds are all well exposed in the railroad cuts, the Oriskany outcropping just north of the station and the limestones a few rods south. Just behind the station there is a synclinal tongue of Esopus shales, which terminates less than a mile south, and in the slopes and ridge east there are upper Shaly, Becraft and lower Shaly beds dipping steeply westward as shown in the lower section, figure 9, and section II, plate 7. The Becraft beds are deeply quarried on the summit of the ridge and are well exposed at a number of points along the rim of the synclinal southward.

On the western limb of the main Rosendale-Whiteport anticlinal there are a number of flexures which come in from the north and northwest and gradually pitch up to the southward. They are first observed as low undulations in the Onondaga limestones and Esopus shales about Hurley, as before mentioned. They bring to the surface the Oriskany sandstones and Helderberg limestones in the region southwest of the upper Binnewaters, and along Rondout creek they bring up the cement series over a considerable area. Their general relations are shown in plate 7, and in part in figure 7. The first of these subordinate anticlinals westward is finely exhibited in a cliff at a point on the northern shore of the fourth Binnewater, where the upper Shaly and Oriskany members are flexed in a graceful arch. This flexure merges into the general anticlinal south of here and is lost. To the west of this flexure there is a synclinal holding a very narrow ridge of Esopus shales which extends to a point nearly west of Binnewater station. West of this synclinal there is an anticlinal of considerable prominence. It brings up the Oriskany in a symmetrically rounded ridge in a depression amid the Esopus ridges, in the fork of the roads a mile and a half due west of Whiteport. This ridge rises gradually southward, and in a half mile the Oriskany is eroded through on the summit and the upper Shaly and Becraft limestones constitute its crests to beyond the road from Binnewater station to Cottekill. Its structure is shown on the left end of the section in figure 7.

Rondout creek crosses these flexures above Rosendale, and the lower limestones and the cement beds are extensively exposed along its northern bank. The first synclinal west of Rosendale is the one that holds the long, narrow ridge of Esopus shales northwest of Binnewater station. It is a shallow basin in the cement rock, of which the bottom is near the level of the creek, and the beds have been worked to a considerable extent down both the slopes. On its western limb there is a small local fault which offsets the cement beds a few yards. Its relations are shown in the fourth section, on plate 7. In the anticlinal next west the Shawangunk grit rises forty feet above the creek bed and extends up the Cottekill. The cement beds and underlying formations are exposed on both flanks of the flexures and they cross the kill in succession a short distance above its mouth.

West of these flexures there are several others which rise in the region about Cottekill post-office and are of considerable prominence in the Rondout valley, as shown to the left of the middle of the fourth section on plate 7. They comprise two principal anticlinals, of which the easternmost crosses Rondout creek at the mouth of the Coxingkill and the westernmost at the big bend west of the turnpike bridge. The arch of the latter anticlinal is superbly exposed in cliffs of

PLATE 10.

FALLS OF RONDOUT CREEK OVER THE CEMENT BEDS, HIGH FALLS, N. Y. LOOKING NORTHWEST.

Pentamerus limestone along the creek and canal in this bend. Its character is illustrated in the following figure:

FIG. 10.— Arches of Pentamerus limestone on Rondout creek just west of the bridge on the turnpike from Rosendale to High Falls. A., south bank; B., north bank.

A short distance southwest there is either a slip or slight anticlinal in the general synclinal and not far beyond there is exposed in the canal bank, a low arch in lower Shaly limestone of which the western limb extends thence westward as a monocline.

The pitch to the northward is steep in the vicinity of Rondout creek in the Rosendale region and for some miles above and as shown in the following figure. The main arch of the Rosendale-Whiteport anticlinal brings up the Shawangunk grit south of the creek.

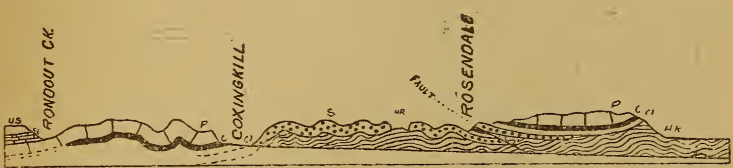


FIG. 11.— Cross section along the south side of Rondout creek through Rosendale. Looking north US., Upper Shaly and Becraft limestones; P., Pentamerus and Tentaculite limestone; C., Cement series; Cl., Clinton and Medina; S., Shawangunk grit; HR., Hudson river shales.

From the highest arch, this formation is removed and the Hudson river shales extend nearly to Rosendale. Along the eastern side of the lower Coxingkill valley, the Shawangunk grits dip down a steep slope into a meadow underlaid by the Clinton and Medina formations and the cement series, as shown in figure 11. West of the kill there is a high ridge of Pentamerus limestone which extends to the Rondout creek where it exhibits the arch shown in figure 10. The eastern side of this ridge is a synclinal which widens considerably in the vicinity of Bruceville and continues up the Coxingkill valley far southward into the Shawangunk mountain. It holds the Clinton-Medina members, the cement beds and the Tentaculite and Pentamerus limestones for several miles, when the upward pitch finally brings the Shawangunk grit to the surface. The distribution of the formations in this flexure are shown on the geologic map and the structure is represented in the lower section of plate 7, and the two northern sections on plate 12. Two miles southeast of High Falls, the synclinal divides into two synclinals, with an intervening anticlinal ridge. The Coxingkill comes down the valley west of the ridge, and the outlet of Lake Mohonk is into a valley on the east side. Up the latter the Clinton and cement beds extend in a narrow belt, carrying in its center an outlier of Tentaculite and Pentamerus limestones which give rise to a small ridge. The cement series is covered by drift and debris in the greater part of the Coxingkill district and there is some doubt as to the boundaries, but it outcrops at the road forks south of Bruceville and it is mined near High Falls. These mines are in the western arm of the synclinal and the galleries extend for a considerable distance down the slope eastward. The cement is carried across the low ridge on which High Falls is built, by a wire rope tramway which extends to the canal. This ridge is due to Shawangunk grit, which rises a mile north of High Falls along a broad anticlinal in which are combined the flexures shown to the left on the fourth section in plate 7. The cement beds extend around the northern point of the ridge, cross the creek and canal a short distance above High Falls and continue northward along the west bank to the falls. They are not well exposed north of the village, but they cross the creek again to the west and give rise to the falls. These falls are shown in plate 10, and in plate 11 there is represented a portion of the north side of the gorge below, in which the members underlying the cement are finely exposed.

The principal cement bed in this vicinity has a thickness averaging fourteen feet. There is a thinner slaty cement bed below with a thin intervening series of waterlimes. The cement is

PLATE 11.

North Branch of Rondout Creek at High Falls, N. Y.; Exhibiting the Relations of the Clinton Formation. Looking Northwest.

worked in several quarries along the east bank of the creek above the falls. In the gorge below the falls there are forty feet of supposed Clinton to Medina members underlaid by the Shawangunk grit. The beds dip gently to the westward except at a small local anticlinal which crosses the creek near the falls, as shown in plate 11. The rocks in this exposure are principally gray sandstones above and red shales below, with a calcareous sandstone bed intervening. The upper sandstones are thin-bedded and only moderately hard in texture. They contain several thin beds of shales of gray color and some of a dull red tint. The intermediate calcareous bed is about seven feet thick and gives rise to a small fall in the creek. which is shown in plate 11. It is a fine grained, pyritiferous, cement-like rock, but rather more sandy than argillaceous. It is underlaid by a few feet of gray calcareous shales, which merge into the mass of bright red shales lying on the Shawangunk grit at the mouth of the gorge. These red shales contain intercalated beds of buff and green shales and have a thickness of about eighteen feet. They lie just east of the locality indicated on the right-hand corner of plate 11. Mather* described this section in some detail in his report on the first district, but he mistook the thin-bedded sandstones for limestones and I could not reconcile his statements with my observations. Cook, in the Geology of New Jersey,† gives some notes on this section which embody the principal facts.

The upper members in the High Falls gorge is quite unlike the quartzite which characterizes the horizon further northward and they represent considerably different conditions of deposition. Owing to lack of outcrops in the interval the gradation could not be studied.

The Esopus slates occupy a wide area west of Rosendale constituting a region of smallbut very rough ridges, in large part of bare rock. They are black, fine-grained rocks with pronounced slaty cleavage. On the road from Cottekill to Marbletown they are frequently seen and they constitute the ridge on which Stone Ridge village is situated. The structure is mainly a gentle monoclinal with low undulations, as shown on the left of the

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*Loc. cit., pp. 353–354. †Loc. cit., p. 157.

section of plate 7. These undulations are the beginnings of the flexures which extend southward into the Shawangunk mountain.

The Onondaga limestone occupies a long slope along a belt west of the Esopus shales. It is the usual light-blue gray cherty limestone. North of the Cottekill there are several outlying masses on the Esopus shales that are so large I have represented them on the geologic map. They average about twenty feet in diameter and appear to be in place. The dips of the limestones are very gentle to the west into the north and south valley of Esopus creek. West of this valley rise steep slopes of Hamilton shales, but these are deeply and widely trenched by the northwest and southeast portion of Esopus creek.

Shawangunk Mountain.

The Shawangunk mountain lies between the Walkill valley and the southern Catskills. It rises gradually south from Rosendale and finally attains an elevation of 2200 feet and a width of five miles east of Ellenville. It continues to the southward with diminished width and height through New Jersey and Pennsylvania. In these States it is known as the Kittatining or Blue mountain, and it is crossed by the Delaware, Lehigh and Susquehanna water gaps.

The well-known summer resorts of Lake Mohonk and Lake Minnewaska are on the summit of the Shawangunk mountain in Ulster county so that the region has become familiar to a large number of visitors. Unfortunately, however, a description of its geology has never been published and the brief references in the report of Mather* throw but little light on the subject.

The structure of this mountain in Ulster county is a particularly interesting illustration of close relation of rock texture to topography, for the presence of the mountain and its form are directly dependent on the structure of a relatively thin sheet of hard rock. In the accompanying stereographic map, plate 12, an attempt has been made to represent its character, and its structure is shown in the cross-sections at the ends of blocks into

* Geology of New York; Report on the First District. 1843.

PLATE 12.


STEREOGRAM
OF THE
SHAWANGUNK MOUNTAIN
IN
ULSTER CO, NEW YORK
BY
N. H. DARTON
Scale
VERTICAL
HORIZONTAL
=1:3½.
(The Base is at Sea Level.)
HIGH FALLS
NEW PALTZ
LAKE AWOSTING
CRAWFORD
HAMILTON SHALES
ONONDAGA LIMESTONE
ORISKANY AND ESOPUS
HELDERBERG LIMESTONES ETC
SHAWANGUNK GRIT
HUDSON RIVER SHALES

which the supposed model is divided. The mountain consists of a widely-extended sheet of Shawangunk grit lying on soft Hudson river shales. This sheet lies in a gently west dipping monocline which is corrugated by a series of gentle longitudinal folds. To the westward it dips beneath shales and limestones of the succeeding formations in the Rondout valley; to the eastward it is terminated by long lines of high precipices surmounting steep slopes of Hudson river shales. Its anticlinals give rise to high ridges and wide plateaus; its synclinals constitute in greater part the intervening depressions. In several portions of the mountain the grit has been eroded from the crests of the anticlines and the underlying slates are bared. This is the case in a wide area southwest of Ellenville, in a long strip extending from near Lake Mohonk nearly to Rosendale, in a small area east of Wawarsing and in the top of the mountain north of Lake Minnewaska.

The surface of the Shawangunk mountain is nearly everywhere very rugged, and it abounds in cliffs and rocky slopes. These consist of snow-white grits more or less mantled with dark lichens, and they are remarkably picturesque. There are numerous cataracts, many beautiful rock-bound lakes and widely extended views of the Catskills to the westward and the Hudson valley to the eastward. The ruggedness is due to the exceptional hardness of the rocks, the softness of the underlying shales and a tendency to vertical jointing, which gives rise to cliffs and clefts. There are low lines of cliffs all over the surface of the mountain, especially to the southward, but along the eastern face, where the grit is being continually undermined by erosion of the slate, they are of great prominence, in some cases having a height of 200 feet and extending continuously for many miles. The "points" are projections or promontories of the eastern edge of the grit beyond the general crest line, due to a less degree of recession. Buntico point, Paltz point, Gertrude's nose and Sam's point are the most prominent of these, but there are many others of minor importance. The lakes for which the mountain is famous lie in basins of considerable depth and are all near the top of the ridges. They are nearly surrounded by high cliffs of Shawangunk grit which present great variety of form.

The cliffs on the surface of the mountain are of various lengths and heights, and they are bounded for the most part by joint cracks. They face approximately east or west along the principal joints and north or south along cross joints, but there are some in other directions. They are usually in irregular steps on slopes and face each other and inclose depressions of various and varying widths on the plateaus. They are seldom continuous for over a few yards and merge into slopes or planes. The grits nearly everywhere present a basined surface. The basins are depressed an inch or two below the general level and are of various sizes and shapes. They usually contain pools of water and some sand and pebble detritus. They are mostly smooth and even polished, and all over the mountain, but particularly on its western slope, a large portion of the surface of the grit is smoothed or polished. These features are everywhere intimately associated with glacial scratchings and scorings and are probably due to glacial action.

The corrugations in the general monocline of the mountain are a series of anticlines and synclines which traverse the range diagonally from north-northeast to south-southwest and begin in succession from northeast to southwest, their axis rising gradually to the southward. Mather has suggested that the great cliffs of the regions are due to faults, but I find this is not the case. Only one fault was found and this was the small overthrust of the Rosendale region. There are many slight faults of a few inches or feet, but they appear to be entirely in the grit. Begininng at the northern end of the range the principal feature is the anticlinal which brings up the cement beds between Rosendale and Whiteport, as described in a preceding chapter. South of Rondout creek, opposite Rosendale, the upward pitch of this flexure increases rapidly and the Shawangunk grit soon rises into a ridge of considerable altitude. In a short distance from the creek the grits are eroded from the crown of the arch, and to the southward the underlying shales constitute a series of high hills extending along the center of the mountain. The occurrence of these high hills of soft rock is a

PLATE 13.

BUNTICO POINT, LOOKING NORTH.

striking feature. Their existence is due to the former protection of the arch of Shawangunk grit by which they were originally covered. The grit in the flanks of this arch extends down the slopes of the mountain where it dips beneath the overlying formations in the valley on the west side, and extends nearly or quite to the base on the east side. One mile and a half south of Rosendale the mountain has the structure shown in the first section on plate 12, in which it will be seen that the sheet of grit lying along the eastern slope of the mountain is considerably corrugated. This corrugation consists in the main of a western limb dipping more or less steeply eastward and a shallow synclinal, which, at one point, holds a small area of the cement series. At the southern end of this cement area there is a very abrupt anticlinal crumple in the synclinal which extends but a short distance in either direction and then flattens out into the general flexure. The fault extends from the Rosendale cement region and gives rise to a sharp ridge which continues to the first road across the mountain, beyond which it dies out. Along the eastern face of the eastern range of the mountain the dips are in greater part gently to the westward. Along the railroad they are twenty degrees and this is the average for some distance; on the first road across the mountain the dips are sixty degrees, but this steep dip soon gives place to inclinations of not over ten, and toward the southern end of the ridge the synclinal dies out and there is a general, very gentle dip to the east. This grit area lying along the eastern slope of the mountain terminates very abruptly southward in a line of cliffs, and owing to a general pitch which has carried the beds upward to the south, these have great elevation. The cliffs are known as Buntico point and it is one of the most prominent topographic features in the region. Its principal relations are shown in plate 13.

In this plate there is shown the end of the narrow Shawangunk grit area, and a portion of its eastern face which extends diagonally down and along the slope of the mountain to the right. It is terminated on all sides by cliffs, under which the Hudson river shales appear, and these shales constitute the high hills of the center of the mountain to the left, over which the grit originally arched. Unfortunately the photograph from which plate 13 was reproduced was taken under unfavorable conditions and is not as clear as could be desired.

South from Buntico point the eastern crest of the Shawangunk mountain consists of a great mass of soft Hudson river shales which are being rapidly and deeply eroded. They extend south nearly to Lake Mohonk, where the crest of the anticlinal is occupied by grit for some distance.

The grit in the western limb of the anticlinal lies along the western slope of the northern end of the mountain and does not attain the prominence that it has in the ridge terminating in Buntico point. It constitutes a monoclinal ridge with a line of cliffs along its eastern edge above which the hills of Hudson river slates rise several hundred feet. About the northern end of the mountain the grit of this monoclinal extends eastward over a series of shallow flexures which pitch rapidly to the northward, as shown in figure 11. The hills of Hudson river shales sink rapidly in this portion of the region and soon give place to a rocky, undulating plateau of Shawangunk grit which closes over the end of the anticlinal in the vicinity of Rondout creek. To the west of the west-dipping monocline of Shawangunk grit there is the synclinal valley of the Coxingkill, containing overlying members up to the Pentamerus limestone, which was described on a previous page. On the opposite side of this valley, at High Falls, there rises one of the principal anticlinals of the Shawangunk mountain, which soon brings up Shawangunk grit in the low ridge on which the village is built. This ridge gradually increases in width and altitude southward, and near the line of the third section on plate 12 its crest is nearly as high as the ridge eastward, from which it is separated by the synclinal valley of the Coxingkill.

South from Alligerville the mountain widens rapidly as flexure after flexure brings up the Shawangunk grit from the northwestward. The western ridges rise gradually with the upward pitch of the axes of the flexure and finally become the highest part of the mountain east of Ellenville. Southwest of Lake Mohonk the range comprises five of these flexures, together with various small undulations of the beds, and there is a creek in

PLATE 14.

CLIFFS OF SHAWANGUNK GRIT ON THE WEST SIDE OF LAKE MOHONK.

each synclinal. Lake Minnewaska is in the crown of the anticlinal, which rises at High Falls, and Lake Awosting is on the western slope of the same flexure.

These lakes are all situated near the eastern side of the mountain and about 150 feet below the crest. They are similar in relations and originated under almost the same conditions. Lake Mohonk occupies a north and south cleft in the crown of the anticlinal which rises at Rosendale.

The structure of the lake is shown in the following figure:

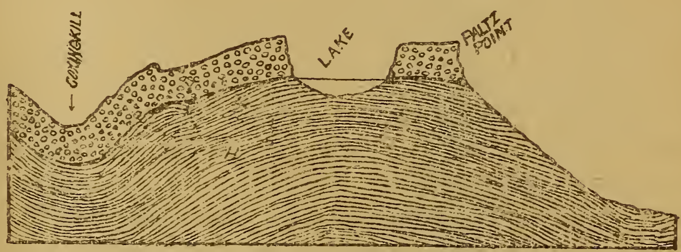


FIG. 12.– Cross-section of eastern ridges of Shawangunk mountain through Lake Mohonk, H., Hudson river shale. Looking north. Vertical scale exaggerated.

The lake basin is in Hudson river shales but it is surrounded on the east and west by high cliffs of Shawangunk grits. To the south there is a gap in the front of the mountain through which the shales extend to the lake. The top of these shales is a few feet above the surface of the lake at its southeast end but the pitch carries them a few feet below the water surface to the north and west.

The view in plate 16 is looking southward and through the gap in the east front of the mountain through which the Hudson river shales extend to the lake. On the left is Paltz point and to the right in the distance there is "Cope point" a projection of the southern extension of the eastern front of the mountain.

East of the lake there is a thick mass of grit which lies along the crest of the anticlinal. It begins a short distance north and is terminated by very abrupt cliffs in Paltz point near the southern end of the lake. The character of this "point" is shown in plate 16, and its relations are represented in the stereogramic map.

At the head of the lake and the base of the south end of the mass of grit at Platz point the Hudson river shales constitute a small plateau which surmounts the long eastern slope of the mountain. There is no cross drainage way at the base of the cliff, and the cause of the abrupt termination of this point is difficult to understand.

The grit dips gently to the west northwest along the west side of Paltz point and very slightly to the eastward in the easternmost part of the range. Northeast of the lake the dip is at a low angle to the westward, but there are several slight undulations. There is everywhere a pronounced pitch to the northwest. Owing to the westerly dip the grits in the Paltz point ridge are somewhat lower just north of the lake than elsewhere. It will be seen from these statements that the lake lies slightly west of the center of the arch of the anticlinal and all the dips along its shores are to the northwest although at very low angles. The degree of dip rapidly increases down the western slope of the mountain to the synclinal valley of the Coxingkill.

The outlet of Lake Mohonk is to the northward by a branch of the Coxingkill. This branch flows through a slight depression separating the Paltz point range from the main mountain mass, and then obliquely down the flank of the anticlinal.

South from Paltz point the eastern front of the mountain presents a nearly unbroken line of cliffs for many miles along or near the crest of the anticline. The nature of a portion of the escarpment is shown in plate 17.

Two miles south of Lake Mohonk there is a slight depression in the crest line through which the road to Lake Minnewaska passes and there are several other depressions of less amount. Millbrook mountain is the culminating feature of the portion of the range beyond which its front is somewhat more irregular in contour.

Lake Minnewaska is similar to Lake Mohonk in appearance, but it is somewhat larger. It was not ascertained whether its basin extends into the Hudson river shales, for there is a continuous rim of grit surrounding it. As a very great thickness of grit is exposed above the water level in this vicinity it seems probable that the bottom of the lake is very near the shales. This probability is increased somewhat by the presence of the

PLATE 15.

LOOKING UP LAKE MOHONK. PALTZ POINT ON THE LEFT.

steep cliffs and the width of the valley or cleft in which the lake lies. In the following figure there are shown the principal structural features at this locality.

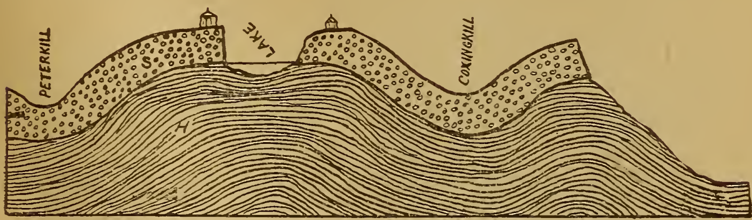


FIG. 13. Cross-section of the eastern ridges of Shawangunk mountain through Lake Minnewaska. Looking north. H., Hudson river shales. S., Shawangunk grit.

The cliffs which extend along the east side of the lake are very high and precipitous. They are shown in greater part in plate 18. As at Lake Mohonk the rocks are greatly fissured and they are traversed by many deep, wide clefts. The dips are gently anticlinal about the lake, which is on the axis of the flexure, but they increase in amount to the east and west.

The lake empties to the southward through a wide gap into the synclinal valley of the Coxingkill, and it may be regarded as the headwaters of this stream.

A mile southeast of the lake the anticlinal in which the lake is situated is crossed by the road to Port Hixon, and in the vicinity of the road the grit has been eroded from the crown of the arch for some distance. The road crosses the ridge in a gap on the Hudson river shales, and the edges of the grit give rise to high cliffs on either side. Down the slope the grit outcrops on the flank of the arch, but the slate extends along the slopes of the mountain for some distance, especially on the east side. The occurrence of the slate in this inlying area is a very striking feature, and the reason for the removal of the grit at this locality is not clear.

South of Lake Minnewaska the front of the ridge trends to the southwest for some distance, and the Coxingkill synclinal and the Minnewaska anticline pass out to the south. There is a prominent "point" in this vicinity known as Gertrude's nose, which is due to a deep incision in the front of the mountain made by a small branch of the Wallkill. This stream heads in the plateau south of the lake, passes over the edge of the grit in a series of falls, and has cut a deep gorge into the Hudson river shales below.

Lake Awosting is the largest lake of the series and is a considerable body of water. It is mostly surrounded by low cliffs and rocky slopes, but near its eastern end there is a very high cliff for some distance which comes in from the crest of the mountain eastward and constitutes a high west-sloping plateau northeast of the lake.

In the following figure there is given a view of this lake, based on a kodak photograph.

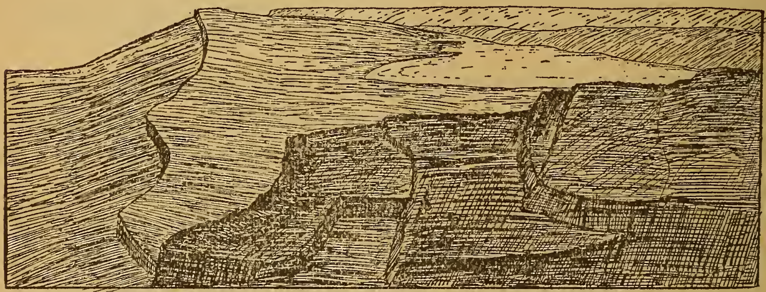


Fig. 14.—Lake Awosting from the east-northeast.

The basin of this lake does not appear to be in Hudson river shales, though possibly they underlie its deeper portions. The grit dips gently west along the shores, and this dip continues over a wide area. To the west is a long slope which extends from a low cliff along the lake to the main Peterkill or Vly Creek valley.

The outlet of the lake is by a branch of the Peterkill which flows along the west sloping grits for a mile and then passes over high falls into the main valley of the Peterkill. To the east of the confluence there is a narrow depression known as the "dark hole," which extends southeastward up the slope of the mountain. It is bordered by moderately high cliffs of east-dipping grits and was cut by a stream which empties into the Peterkill. On its south side is the high plateau of which the eastern front is the cliff at the southeast end of Lake Awosting. Its relations are shown in the stereogramic map.

The Peterkill valley, from beginning to end, flows on the western flank of the anticlinal on which Lake Minnewaska is situated. It has a cliff of west-dipping grit along its west side

PLATE 16.

SOUTH END OF PALTZ POINT. LAKE MOHONK IS IN THE DEPRESSION TO THE LEFT.

and long slopes of grit to the east. Four miles below Lake Awosting the kill passes over "Awosting falls" and then over a series of cascades aggregating in all a fall of 240 feet (approximated). In the Awosting falls there is a clear drop of sixty or more feet. In plate 19 these falls are shown. They are a mile north of Lake Minnewaska and are an attractive feature of that resort.

In the bottom of the gorge below the several falls there are high cliffs of grit for some distance. Owing to a considerable pitch to the north, or down stream, and a thickness of grit somewhat over 200 feet, the falls of this series do not cut through to the Hudson river slates.

South of Lake Awosting there are two small ponds on the summit of the mountain, but I did not visit them. Mud pond is one, at the head of Vly Creek or the principal branch of the Peterkill, and Lake Maratanza is the other. Lake Maratanza empties to the east by a branch of the Wallkill, which pitches over the edge of the mountain a short distance from the lake in a great fall, and into a deep gulf of Hudson river shales. The locality is known as Verkeeder falls and it is said to be a very fine feature.

Between Gertrude's nose and Sam's point the crest of the mountain is very high, but for some distance the edge of the grit is broken into great terraces, and there is a sloping bench of Hudson river shales of some width at their base. Several branches of Walkill drainage head in the crest of the mountain in this region and pass over the edge of the grit in falls, of which the above-mentioned Verkeeder falls are the most noteworthy.

In this region the mountain continues to narrow and most of the flexures pass out to the southward. This narrowing is due to the recession of the edge of the sheet of the Shawangunk grit and is closely related to the upward pitch of the flexures. This pitch increases the height of the mountain southward, but with increased height there is a corresponding increase of erosion in the soft underlying shales, which beyond certain limits causes rapid recession. This is illustrated by Sam's point, where the maximum altitude of 2200 feet is attained. The "point" is a narrowing extension of the grit along the axis of a very flat synclinal, which finally terminates in a high narrow cliff presented southward. From the wide anticlinal area to the west the grit has been eroded and the Hudson river shales occupy the surface in a group of very high hills. These hills are surrounded on the east, south and west by cliffs of the grit which rise somewhat above them to the east are about even with their higher summits on the north, and lie on their flanks to the west. It is the grit on the western limb of the anticlinal that lies on the western flanks of the slate hills, and this relation continues in a monoclinal mountain which extends from Ellenville far southward into Pennsylvania. This monoclinal mountain consists of a single-crested ridge of the Shawangunk grit with a long slope up the dip from the valley to the west, which terminates in an east-facing cliff of grit surmounting long rolling slopes of shales on the east side of the mountain. Its structure near the southern edge of Ulster county is shown in the bottom section on plate 12, and this is typical for the greater part of its course. The dips along the western slope of the mountain are low north of Wawarsing, but they rapidly increase southward to an average of about sixty degrees in the vicinity of Ellenville. In this region of steep dips the streams flowing down the steep western slope have cut deep gorges, which in several cases extend through the grit into the underlying shales. The two streams south of Ellenville are exaggerated examples of this, and they have been largely instrumental in baring the Hudson river shales on the anticlinal axis behind Sam's point. The two streams just north of Ellenville also cut down to the shales, but they are small and have cut only narrow gorges. Opposite Napanoch there is a small creek which cuts a deep gorge into the shales, and in the higher part of the slope has bared an area of considerable size, which is surrounded by great cliffs of the grit. The stream opposite Wawarsing has cut a gorge and removed a portion of the grit in its upper portion, but does not cut through to the slate. The head of this depression extends into the head of the depression opposite Napanoch, and they are surmounted on the east by a continuous line of high cliffs. The stream which flows out of the mountain at Port Hixon is larger than the others and has cut a deep wide gorge, but owing to the lower dip of the grit it does not appear to have cut through to the shales to any great extent.

PLATE 17.

Eastern Face of Shawangunk Mountain from near Lake Mohonk to Millbrook Mountain. Looking South-southeast.

No shales were observed in places in the depression, but a small amount of shale debris was noticed at one point. Everywhere along the steep slopes there are clefts in the grit, some of which appear to extend down to the shales. One of these is the "Ice Cave," a locality which is widely famous in the region. It is high in the slope about two miles east-northeast of Ellenville. Ice and snow remain in it in greater or less amount and in some seasons are preserved entirely through the summer and autumn. The top of the mountain southwest of Wawarsing is a wide plateau which is traversed by the valley of Stony creek. Its surface is very irregular and consists of low cliffs of the base grit.

The relation of the Shawangunk grit to the Hudson river shales in the Shawangunk mountain region is one of slight but persistent unconformity. The coarse grit lies directly on the slate and there is an intervening eroded surface. This erosion has truncated low arches of slate but channeled its surface only slightly. Exposures of the relations are everywhere abundant. One of the best instances is along the road from Minnewaska to New Paltz, at a point two miles south of Lake Mohonk. Here along the mountain slope a very low arch of the grit is exposed with underlying shales in an arch that is plainly seen to be materially steeper. There is divergence of dip in nearly every locality, varying from very slight to ten degrees, but several points were seen where it was hardly perceptible.

The origin and history of the lakes is not entirely clear, but they appear to be due to glacial agencies. The principal feature has been a local deepening and widening of a pre-existing valley, aided, in the case of Lake Mohonk at least, by the presence of shales at the point now occupied by the lake. They do not appear to be due in great measure to damming by glacial or other debris, or to dislocation.

Owing to its prominence the mountain has been long exposed to erosion. Originally the grit was overlaid by a great mass of limestones and shales and the rocks of the Catskill mountain, but these were removed far down into the Rondout valley at an early period. During the glacial epoch there was extensive erosion and the removal of great masses of the grit, some of which are now found in the glacial drift far to the southward. The surface of the rocks was scratched, scored and polished by the pebbles and sand in the bottom of the glacier and these features are conspicuous all over the mountain. Some further account of them will be found on a subsequent page. To the glaciation, too, is probably due the abruptness of Paltz point, the steplike structure over the surface of the mountain and other features of that sort. The sheet of grit originally extended far to the eastward, but by long-continued undermining of the soft underlying shales its front has gradually receded to its present position. This recession is still actively in progress, and every year there fall great masses from the front of the mountain. One of the regions of weakness is Paltz point, for the shales at its base are exposed to erosion on several sides and fragments of the grit will fall off as the undermining progresses until finally the mass will disappear. Probably before it is gone the streams heading near its southern end will cut back through the slates at the head of Lake Mohonk and this beautiful body of water will be drained off. Of course this is all very remote as human history goes, and artificial means will stay its progress in some measure; but it will all be accomplished in the near future, geologically speaking. Lakes Minnewaska and Awosting lie so far back from the front of the mountain that they will survive Lake Mohonk a long time.

The Rondout Valley from above High Falls to Ellenville.

The most prominent features in this valley are wide areas of superficial formations which cover the underlying rocks. These rocks comprise the several members from Onondaga limestone to Clinton shales, but owing to the drift covering they are but rarely exposed. Their distribution as shown on the geologic map is in great part based on widely separated exposures and there are areas of considerable size for which there is no definite information as to the distribution of all the beds. The structure of the region is a monocline dipping to the northwest and west. The strikes are northeast to the vicinity of Port Jackson, east-northeast to Port Hixon, and north-northeast to Ellenville and beyond. The dips are very gentle north of Port Jackson, but they gradually increase in amount to the southward. At Wawarsing, the maximum dips average thirty-five degrees; at Napanoch forty-five degrees; at Ellenville forty-five degrees; and they continue at this altitude beyond Homowack. The

PLATE 18.

LOOKING DOWN LAKE MINNEWASKA, N. Y.

steepness of this dip gradually decreases westward and gives place to a very gentle inclination to the westward. It also decreases to the eastward on the summit of Shawangunk mountain. The southern and eastern side of this valley is the long western slope of the Shawangunk mountain with its bare flanks of Shawangunk grit. To the westward are long spurs of the foothills of the Catskills.

A mile west of High Falls, just west of the turnpike to Ellenville, there are exhibited in hill slopes the lower Shaly, Becraft and upper Shaly limestones and a short distance south the lower Shaly beds are seen along the turnpike. Along the ridge westward on the road to Kripple Bush, the Becraft and upper Shaly limestones are seen, capped by the Oriskany which extends over an area of considerable width sloping to the westward. This area is succeeded by a sharp rise due to a wide ridge of Esopus shales, which is a marked feature from Stone Ridge for twelve miles southward. The Esopus formation here consists of very hard dark slates which merge into an upper member of dark slaty sandstones. On the western slope of this ridge, as in the region northward, the Onondaga limestones extend to a valley of considerable width, in greater part heavily covered with drift. The relations of these features in the exposures extending from Kripple Bush eastward are shown in the following figure:

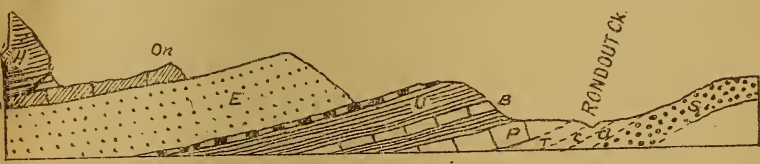


FIG. 15.—Cross-section from the Rondout valley to a point beyond Kripple Bush. Looking north. S., Shawangunk grit; Cl., Clinton and Medina shales; C., Cement series; T., Tentaculite limestone; P., Pentamerus beds; L., Lower Shaly limestone; B., Becraft limestone; U., Upper Shaly limestone; O., Oriskany limestone; E., Esopus shales; On., Onondaga limestone; H., Hamilton shales.

The Clinton and Medina shales are rarely exposed in this valley, and the description of their occurrence at High Falls will answer for the entire region so far as I have seen them. The cement bed was not found between High Falls and Port Jackson, as the creek apparently runs over drift lying in a trough excavated along the cement horizon. The Pentamerus beds were not seen between High Falls and Accord, but it is probable that they underlie a well-marked terrace which extends near the turnpike. Between Accord and Pine Bush they are exposed at several points in low cliffs by the turnpike. At Port Jackson there is a low anticline extending from the western ridge of the Shawangunk mountains, and the Pentamerus beds rise on its western flank, giving rise to a short ridge of moderate prominence with cliffs of limestone fifty to sixty feet high. The Tentaculite limestone and cement beds are obscurely exposed at the base of the southeastern side of this ridge. The cement is said to be of considerable thickness and excellent quality, but the outcrops were too obscure for me to ascertain the correctness of these statements. Stony creek passes just south of this ridge, and on the opposite side of the creek there are exposed the red beds of the Clinton formation, outcropping over the point of the anticlinal, which is here pitching quite steeply to the northeastward.

The lower Shaly limestone was not observed in this region or southward. The Becraft limestone was seen, however, at a number of points presenting its usual characteristics of a light-colored, semi-crystalline, massively-bedded limestone, containing an abundance of fossil shells. Its thickness appears to be considerably diminished, although no complete sections were found. On a hill just south of Millhook, the outcrops cover a considerable area and at this point and in the vicinity it has been burned for lime. The Oriskany sandstone is exposed at Millhook at the milldam. It consists of a very dark silicious limestone below with dark quartzites above. At the locality above referred to, southeast of Kripple Bush, its thickness is at least ten feet and at Millhook it is about the same. The Onondaga limestone has been extensively quarried at many points in this valley, between Stone ridge and Kripple Bush, at Whitfield, about Pattankunk, at Wawarsing and near Napanoch. The formation is, as usual, a light-colored, relatively pure limestone, with occasional lenses and irregular layers of flint. It yields an excellent lime and would furnish fine building stone in localities where there is a sufficient thickness of beds free from chert. A mile northwest of Pine Bush, on Mombaccus creek, the contact of the Esopus shales and the Onondaga limestones is exposed. The upper

PLATE 19.

Awosting Falls of the Peterkill near Lake Minnewaska.

beds of the former are dark quartzitic sandstones, which give rise to a falls at this point. The basal portions of the limestone do not contain the thick beds of passage which exist further north, but it gives place very abruptly to the sandstones. About Wawarsing there are a number of exposures of several formations. Along the turnpike a mile east of the village there is an outcrop of the lower beds of the Esopus formation. They are black slates, separating along cleavage planes dipping steeply to the eastward. Their bedding is obscured by this cleavage, but it may be seen in some portions of the exposure dipping steeply to the westward. On the east side of the road the Oriskany formation is exposed in a low knoll; it is a silicious limestone ten to fifteen feet thick, dipping west-northwest thirty-five degrees. At the road forks the Onondaga limestone appears and is quarried and burnt at this point. Forty feet of this formation are exposed in this quarry, but there are more beds of it under the drift on either side. It is again seen at Napanoch in a quarry out in the meadow east of the turnpike. Here it originally came to the surface in a small knoll, and it is said that there are several similar small showings in the neighborhood. There are sixty feet of beds exposed in the quarry, dipping west-northwest forty five degrees. Between Napanoch and Homowack there are no natural exposures of the Helderberg formation or of the immediately overlying rocks. It is stated that in the excavation for the canal, limestone was found near Homowack, and it is probably the Pentamerus bed, for the Shawangunk grits are exposed a short distance east. All the beds dip very steeply to the westward in this portion of the valley, and the Hamilton shales extend, together with the underlying formation, out under the lowlands east of the turnpike. The high hills rising to the westward are of the hard flaggy beds of the middle and upper Hamilton group which constitute a range lying between the Sandburg-Rondout valley and the Catskill mountains. This range is cut across by the Beerkill, Rondoutkill, Vernovy creek, Mombaccus creek and Metacahonts creek which flow through deep and rocky gorges. The beds are gray sandstones and flags with black shale intercalations and they are nearly everywhere exposed in the hill slopes and along the streams. They dip steeply to the west-northwest about Ellenville and Napanoch, but this dip gradually decreases both to the north and to the west.

At Honk falls there is a fine exhibition of the steep dipping flaggy beds and this feature is shown in plate 20.

The dip at this locality is about forty-five degrees, a mile and a half west it is thirty degrees, and in the upper flag series, two and a half miles above the falls, it has decreased to ten degrees; at Lackawack it is not over three degrees.

THE CATSKILL MOUNTAIN REGION.

The Catskill mountains consist of a great thickness of sandstones and shales, dipping gently to the westward. These members comprise the greater part of the upper flag formation, overlaid by the red conglomeratic sandstones which constitute the higher portions of the Slide mountain range and extend westward over the high ridges between the west branch of the Neversink and the Delaware county line. There are also on the very high summits of the Slide mountain range the light-colored, conglomeratic sandstones. In the mountains north of Esopus creek the conglomeratic members are not represented, although there are occasionally intercalated, at somewhat lower horizons, thin streaks of a conglomeratic character. The idea which has so long prevailed that the higher peaks of the Catskills are capped by remnants of a great sheet of conglomerate is erroneous, at least in the Ulster county region, for the conglomerates are in streaks and at several different horizons. The stratigraphy of the Catskill region is not uniform throughout and there are variations in the characters of the beds in different districts. The greater part of the lower series contains flagstone beds of great extent which have been quarried at a number of localities along Esopus creek and its branches and along the eastern front of the mountains.

The flags occur at various horizons, but the beds do not appear to be constant in character throughout. It is exceedingly difficult to trace them for any great distance, owing to talus on the slopes. The intercalated red shales occur in greatest force in the lower members, where they are numerous and thick. They are not continuous beds but give place to flags, in some cases very

PLATE 20.

Honk Falls, near Napanoch, N. Y. Over Inclined Beds of the Lower Flag Series. Looking North.

abruptly. The red shales occur in greatest amount to the northward and in lower members. Southward they become unimportant features of the stratigraphy, but there are several beds conspicuous in the lower members and others are contained at long intervals above. To the northward in the Overlook mountain region, they occur in frequent succession from the base of the mountains far up the slopes. Along the Esopus valley the red shales often occur in the lower members, but they are rare above. In the high region in the western part of the county, the formations are piled up to a thickness, which is not far from 4000 feet. Owing to frequent variation in the amount of dip, estimates of thickness for wide areas cannot be made with any degree of accuracy without elaborate measurements, and these I had not the time to make. A section through Slide mountain and adjoining ranges is given in the left end in figure 1, and this is typical for the higher bank of the southern Catskills.

The upper flag series in this portion of the region consists of thin to thick-bedded sandstones of moderately coarse grain, from brownish-gray to greenish-gray in color, sometimes reddish, with occasional intercalations of red shale which were not well exposed in the outcrops that I saw. This series grades above into coarser, thicker-bedded red sandstones containing quartz pebbles disseminated and in streaks of varying thickness. The rock cannot be considered a conglomerate except in some cases locally, where the conglomeratic portion attains a thickness of two or three feet and the pebbles are relatively close together. This, however, is rarely the case and such beds soon give place laterally to members characterized by a predominance of finer-grained material. The thickness of the series in Slide mountain is 1375 feet, but it thickens considerable to the westward of Hardenburgh township, where it is not less than 1500 feet. It constitutes the upper part of the Wittemburgh range and extends nearly to the edge of the county in the ridge between the upper Rondout and the east branch of the Neversink. Its western extension was not carefully studied, but the same characters appear to persist into Delaware county. These red beds are cut through by the Neversink and its branches, by the headwaters of Big Indian creek, and their divides, by Dry brook, Mill brook and the Beaverkill and are cut off by Rondout and Esopus creeks, beyond which they do not appear.

The white conglomeratic beds are separated from the underlying members by thin streaks of red shale, but this may be only a local feature. On Slide mountain the beds consist of gray, buff and greenish-buff, coarse sandstone, with scattered pebbles and streaks of pebbles, which attain a thickness of 350 feet in the higher summit of the mountain. There is a small cap of the formation on Mount Cornell, also on Wittemburgh and apparently also on Table mountain, Panther mountain and Peak-o-Moose. It was thought that the western dip should carry this formation down to Double Top and Graham mountains, but these exhibit only the red conglomeratic beds at their summits. It is, however, possible that the white beds are only a local phase of the eastern extension of the red deposits.

In the northern Catskills, in Woodstock township, particularly on Overlook mountain the Upper Flag series is extensively exposed. Ascending from Woodstock village to Overlook mountain there are alternations of red shales and gray or greenish-gray flags all the way to the top. At an elevation of about 300 feet above Woodstock there is a particularly heavy bed of red shales which has a thickness of forty feet, and there are other thick beds near the summit. The summit is a cap of hard, gray, flaggy sandstone twenty-five feet thick, lying on twenty-five feet of red shales. Along the road which passes just northward there are some alternations of underlying gray sandstones with thin streaks of red shales. At one point north of the hotel about two hundred feet below the summit, there are thin streaks of quartz conglomerate, of quartz and quartzitic pebbles in a gray sandstone matrix and again at a point 500 feet below this horizon several thin conglomeratic streaks are exposed on the southwest slope.

Southeastern Townships.

The region extending from the eastern face of the Shawangunk mountains to the Hudson river is occupied by the Hudson river formation. The greater part of the area is underlaid by slates and shales, but to the eastward in the high ridges extending from near Marlborough to Rondout there are sandstones and grits occupying a considerable area. Much of the slate region is gently undulating with many low ridges of drift, and it is traversed by the wide valleys of the Wallkill and Swartkill,

PLATE 21.

WITTEMBERG RANGE, SOUTHERN CATSKILLS. LOOKING WEST FROM WEST SHOKAN.

which are covered by alluvium. Slate outcrops are frequent, but the finest exposures are in the slopes of the Shawangunk mountain, along the Wallkill and in the bank of the Hudson river.

The predominant material is a brown-gray to black, moderately hard, fissile slate, often with marked cleavage and obscure bedding. There are many local intercalations of fine-grained sandstones, in greater part of dark color. At Rifton glen the Wallkill cuts deeply into the formation, and there are several extensive exposures in the banks. The beds are mainly horizontal, massively-bedded, fine-grained sandstones, with thin intercalations of shales. They are considerably broken below the falls, owing to local faults of small amount, and they are also considerably arched. Fossils occur at this point, comprising a number of distinctive Hudson river species. Near Eddyville the slates and sandstones are extensively exposed in the banks of Rondout creek, overlaid to the northward by the Salina and lower Helderberg formations. At Eddyville the slates are greatly contorted, and there is a fine exposure of these contortions in the creek banks. Along the eastern flanks of the Shawangunk mountain the Hudson river beds are soft shales, and these also, as already mentioned, are conspicuous in the eroded areas within the mountain, notably north of Lake Mohonk, at the southern end of Dickebar mountain; in the high hills of Mount Meenahga and in the gullies on the west slope of the mountain near Ellenville and Napanoch. In the vicinity of the Shawangunk mountain the slates dip northwest, with slight unconformity to the overlying Shawangunk grit, as already explained, but to the eastward the dip is to the southeast over a wide area extending to and beyond the Walkill river. The angles vary from thirty degrees to vertical, but from fifty degrees to seventy degrees are most frequent. The structure of the slates in the Walkill valley was not worked out, owing to the lack of definite stratigraphy and the absence of continuous outcrops along cross-section lines. Marlborough mountain and its northern continuations through Lloyd and Esopus townships are a series of high, narrow parallel ridges, consisting of hard, dark-gray, flaggy sandstones of moderately coarse grain. The beds stand nearly vertical and their structure is not clear. There are apparently several distinct series of beds of these coarse sandstones, separated by slates and sandy shales of moderate thickness. The section east of Highland station is given in the following figure:

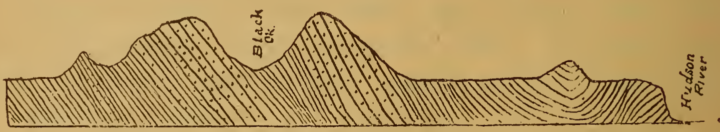


FIG. 16.—Section through the northern end of Marlborough mountain from Clintondale station to Highland station. Looking north.

The intermediate slate in the valley of Black creek was found to be abundantly fossiliferous with a Hudson river fauna. No fossils were found in the sandstones. A characteristic feature of these sandstones is the occurrence of disseminated pebbles and conglomeratic streaks of lighter-colored sandstones, of blue-gray limestones of calciferous aspect and angular fragments of hard, dark slates. No fossils were found in this conglomeratic material but no extended search was made for them. The conglomeratic streaks occur at several horizons apparently, but they are at a considerable distance from the adjoining slates. These coarse-grained members give place in part to finer-grained quartzitic beds at some localities especially in the ridges north of West Park station. They are best exposed in the deep cut of the West Shore railroad between West Park and Esopus, where there are seen massively-bedded, red quartzites standing nearly vertical or dipping steeply to the southwest. Near Black creek, a few yards from the railroad, these beds were quarried for abutments for the railroad bridge, and although very hard and difficult to work they afford an excellent material for such purposes. The high ridges of hard beds extend west from Esopus nearly to the Rondout creek, but are crossed by a relatively low depression at Ulster park. To the eastward of Marlborough mountain and its northern extensions there is a belt of slates similar to those of the Wallkill and Swartkill valleys, but containing many intercalated fine-grained sandstones which extend to the Hudson river. The beds are finely exposed in the river banks, partly in the many cuts of the West Shore railway. The slates in these cuts are mainly gray, highly cleaved and steeply dipping. To the south of New Paltz landing the cuts are particularly deep and exhibit a great variety of structural features in gray slates. Near the landing the dips are to the westward, forming a synclinal between the river and the high ridges of coarse rock westward. To the northward, part of this synclinal extends to the river and is exposed in the railroad cuts. The rocks involved are gray sandy shales and gray, flaggy, fine-grained sandstones. The shales are abruptly terminated south of Marlborough by a fault which brings up the Wappinger limestones.

The limestones occupy a small area in the extreme southeastern corner of the county. They are exposed in cliffs and railroad cuts extending continuously along the river bank to the Orange county line. They extend westward in rolling hills of typical limestone character, with many scattered outcrops. The dips are to the westward throughout, at an angle of ten degrees along the railroad and somewhat more in the hills west. In the vicinity of the fault there is considerable local disturbance, mainly fracturing. The relations of this fault are quite clearly exposed in the river bank, and in the following figure a sketch is given of the principal features.

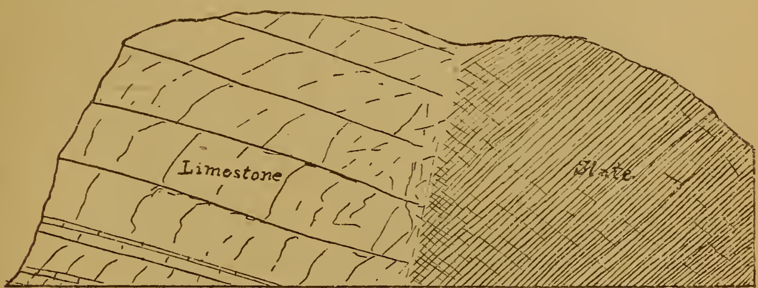


FIG. 17.—Section of fault one-half mile south of Marlborough station, on the Hudson river. Looking west. Based on a photograph.

The fault extends to the southwest and then west-southwest and passes out of the county. Its course inland is marked by an abrupt break between the rounded hills of slate and the knobby surface of limestone.

The limestone has been quarried to some extent, and in a quarry a short way above the railroad some of its upper members are well exposed.

As the stratigraphic relations of the limestones to the adjacent slates is not known the amount of the fault could not be determined. It crosses the Hudson northeastward, where it has been studied by Dwight.*

Pleistocene Geology.

The Pleistocene formations consist of glacial drift of various kinds, alluvial accumulations and stratified clays and sands. I have not made a special examination of these formations and have but little to offer regarding them. The region has been extensively glaciated, and in some localities the products of glaciation are quite conspicuous. These are masses of drift, in greater part consisting of thin, irregular sheets extended over wide areas, and glacial striæ, scoring and polishing preserved on the surface of the harder rocks. The Shawangunk mountain presents the clearest evidences of this glaciation, which is conspicuous over nearly its entire area. This feature has been referred to by a number of observers, and Julien † has recorded the direction and nature of the striation at many points as follows:

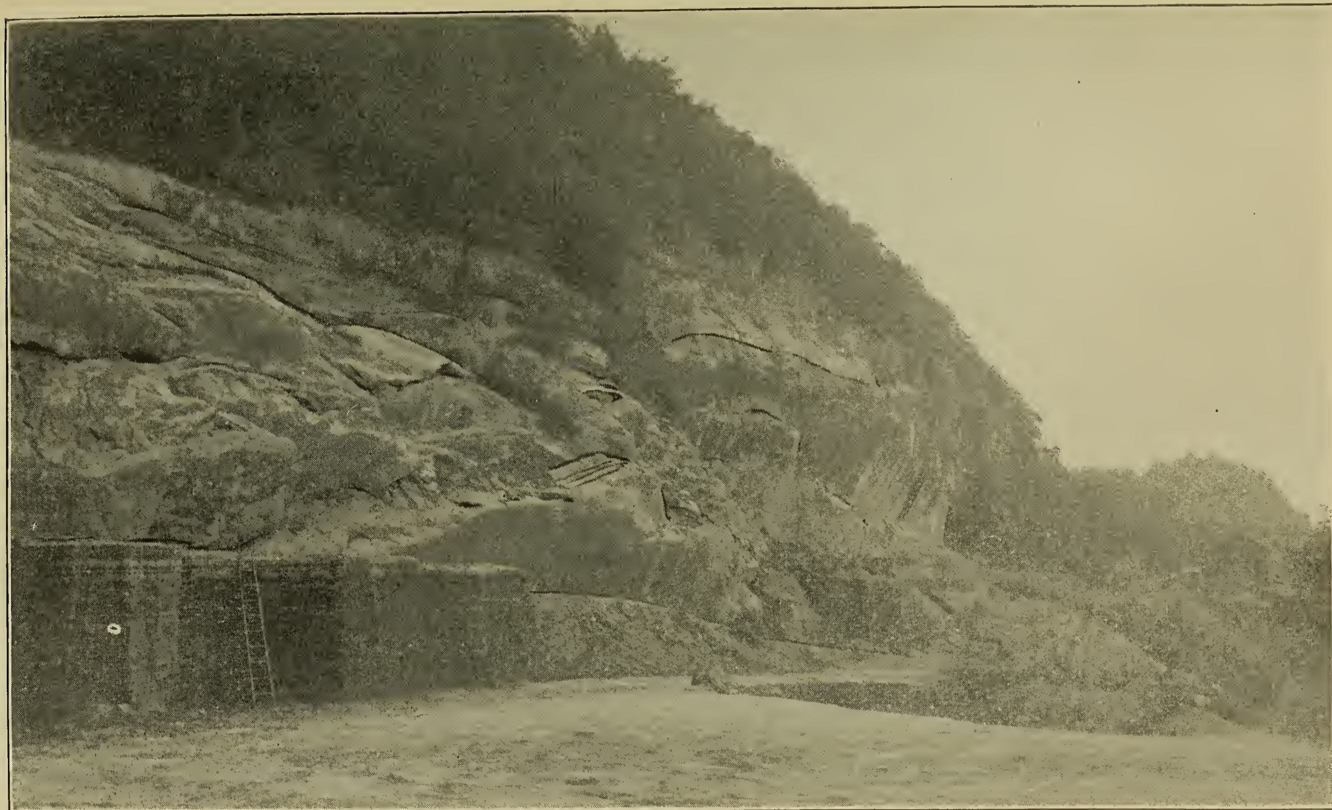
"In the Sam's point region they are northeast and southwest, varying a few degrees on either side. Those trending south twenty-nine degrees west are most abundant, and there were fifteen to a foot, mostly about one-sixteenth of an inch deep. A few one-quarter of an inch in depth trended south seventy-five degrees west and south eighty-six degrees west. In following a long scratch southward there seemed to be a tendency to curve more and more toward a point nearer the west. In the vicinity of Lake Mohonk south ten degrees west was the direction observed at many points on the northwestern side of the mountain, and south forty degrees east on the southeastern side, and south eighteen degrees east on "Sky Top" at the summit of Paltz point; on the road to Alligerville south forty degrees east on the northwestern slope of the mountain. At Lake Minnewaska the direction is given as south ten degrees west."

It is suggested by Julien that the southeasterly direction on "Sky Top" may record the direction of the older and thicker glacial stream, while the others are due to local variations in

* Am. Jour. Science, III, vol. 31, pp. 125–133; one plate, 1886.

† New York Acad. Science, Trans., vol. 3, pp. 22–29.

PLATE 22.



Champlain Clays lying against the Old Shore-line of Helderberg Limestones in Brickyards along the Hudson River, One Mile North of Rondout, N. Y. Looking Northwest.

depressions. Polishing is a very conspicuous feature on the mountain. The surfaces are frequently almost glassy, particularly on the higher portions of the western slopes where there are wide areas of polished surfaces. This may be due in part to local erosion and ice action. In the flag and Catskill regions the scoring and striation is frequently seen. The direction is mainly north-northeast to south-southwest, but is very variable within limits of a few degrees, particularly in the lower altitudes.

The alluvial deposits of Ulster county comprise sands, gravels and boulders along the streams and peat and marl deposits in some of the adjacent lowlands. The upper valleys of Esopus and Rondout creeks contain a large amount of relatively recent gravels and boulders more or less intermixed with sands, and nearly all the small stream depressions contain similar deposits at intervals. There are along the wider valleys of the eastern part of the county extensive deposits of stratified clays and sands and in the lowest terraces greater or less accumulations of recent alluviums. The clays and sands constitute a terrace of varying width bordering the Hudson river to below Port Ewen and extending up the Rondout creek by Ellenville, up the Wallkill to Orange county and a long distance up Esopus creek. They are the products of a submergence at the close of the glacial epoch, which is known as the Champlain period. During this submergence the waters of the Hudson extended over the area now occupied by the deposits, which have since been elevated and cut into by the present drainage.

These deposits extend up to an altitude averaging about 250 feet to the westward and to considerably less along the Hudson. They consist normally of a clay deposit below overlaid to a greater or less thickness by sand. At points where the streams entered the submerged area at the time of the deposition of these deposits there are also found delta deposits of coarser materials. The clays lie on thin, irregular masses of glacial sands and gravels or on glaciated surfaces of rocks. Mr. Heinrich Ries * has recently published a preliminary account of these

* The Quaternary deposits of the Hudson River valley between Croton and Albany, with notes on the brick clays and the manufacture of brick. 10th annual report, State Geologist, 1890. 110–155. Albany, 1891.

deposits in the Hudson valley, and from this work the following observations are taken:

From Glasco to Rondout the terrace, which is perhaps one-eighth of a mile broad at Glasco, narrows as it nears Rondout and has an average height of 150 feet. The clays, so far as could be ascertained, lie on the upturned edges of the shale. In the Van Dusen yard at Glasco the clay is in places "as much as seventy feet thick and is mostly blue, with several feet of loams on top." The clay lies on a ridge of shale which rises steeply from the shore for some sixty feet. "At the Washburn yards the blue clay has a thickness of 132 feet, with four feet of yellow clay and six to eight feet of fine sand above. It lies on shale at an altitude of eight feet above the river." At the rear of A. S. Staple's yard (two miles north of Rondout) there is an exposure of "hardpan" underlying the clay. The overlying material at this locality consists of sand and gravel, in some cases stratified and sometimes cross-bedded. The sand in some spots is ten to fifteen feet thick and fine enough to be blown by the wind. At Hutton's yard (near by) the blue clay is exposed from eight feet above tide to 110 feet; above this there is about ten feet of yellow and over this about fifteen feet of sand.

At Port Ewen the clay is mostly blue, resting on a mass of hardpan and in a few places on the glaciated rock surface. The clay seems to lie as a deposit eighteen to twenty feet thick on the hardpan and is in turn overlaid in many places by fine stratified sand. A point worthy of notice is the difference in level of fifty feet between the terrace at Port Ewen and that at Glasco. This may be due to the fact that when sediment is deposited in a basin its upper surface will be higher at the edge of the basin than in the center. The quaternary formation broadens out at Port Ewen toward the west and Port Ewen would be on a point of the basin's edge, while Glasco is near the center. At Port Ewen the terrace is 207 feet above the river, but it must be fully 225 feet at the base of Hussey mountain, which was probably an island in the estuary.

The thickness of the clay between Glasco and Rondout varies considerably, amounting to 120 feet in places, and in others not over twenty feet. This is owing to the great irregularity of the underlying rock surface.

PLATE 23.

TYPICAL FLAG OR BLUE STONE QUARRY, QUARRYVILLE, N. Y. LOOKING NORTH.

The narrowest part in the terrace is a mile north of Rondout, where its width is not over 200 yards. In the yards of Terry Brothers the clay has been quarried back to the old shore line of the deposits, which is a high overhanging cliff of Helderberg limestone. The relations at this locality are shown in plate 22.

This high, steep shore extends for some distance in this region, but lies farther back from the river elsewhere.

In the Walkill, Rondout and Esopus valleys the Champlain deposits are thick and extensive. East of Rosendale there is a wide sand plain of the upper member extending from the Rondout creek to the Walkill. In the Rondout valley above High Falls the clay deposits are very thick and they rise in high terraces along the turnpike and eastward. At Pine Bush the sand member is conspicuous, constituting a high, narrow ridge trending eastward and separating the Mombaccus and Rondout creeks. The lower portion of this ridge is clay apparently, which extends to its base.

It is thought that the low divides of the Catskill are due to glacial action, mainly to the diversion of streams by ice dams

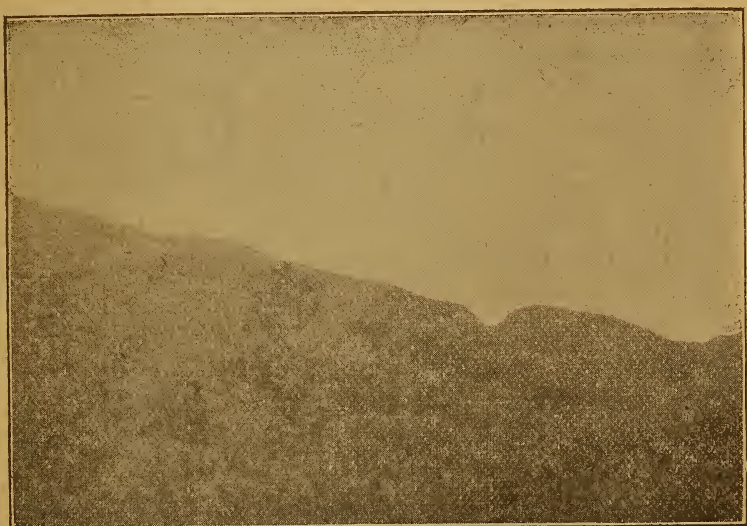


FIG. 18 — Wagonwheel gap from Sampsonville. Looking north.

Possibly they were in part pre-existent as part of an early base level system, but this possibility has not yet been carefully considered. They are largely in the direction of the ice movement, notably Stony clove, Mink hollow, Peak-o-Moose clove and Big Indian divide. One of the most remarkable of these features is in the southern Catskills. It is a gap across the long eastern spur of "High Point" mountain. It is known as Wagonwheel gap and is a conspicuous feature in the region. Its character is shown in the preceding figure.

The gap is cut across the spur very much after the manner of a high railroad cut, but its bottom slopes from a divide near its center. Its depth is about 200 feet. It is, I believe, a product of glacial times and was cut by Esopus creek while the valley was dammed by ice in the vicinity of Shokan. I have not studied the locality with care, and this should be regarded only as a suggestion.

Respectfully yours.

N. H. DARTON.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Economic Geology of Ulster County.

JAMES HALL, State Geologist | FRANK L. NASON, Assistant

1893.

PLATE 1.

View of the New York and Rosendale Cement Company's Mines, Rosendale, Ulster County, N. Y. The High Trestle on the Left is the Walkill Valley Railroad Bridge over Rondout Creek. Looking Northeast.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

ECONOMIC GEOLOGY OF ULSTER COUNTY.

By FRANK L. NASON.

JAMES HALL, *State Geologist:*

SIR.— The natural resources of Ulster county reach through a wide range of geologic time. The mineral from which metals are extracted give numerous traces of their existence, but all attempts to work them have proved failures.

Veins or crevices in the rocks of the Shawangunk grits have yielded lead, copper and zinc sulphides; limonite or bog iron ore has been found and worked to some extent in the valley of Rondout creek near Napanoch. The usual tales of the finding of gold and silver, both among the Shawangunk and the Catskill mountains, are current, but even the credulous are too wise to invest money in this useless search.

Among the Catskills the expectation of finding coal is often voiced, "if you only go deep enough," and this belief is still firm in the minds of many, in spite of the fact that geologists have long since pointed out that if coal or coal-bearing rocks were ever found in this region the last trace was swept away ages ago. Often the expression is heard, "if there isn't coal or mineral in these mountains what are they good for?" These persons forget the numerous quarries that are almost limitless in extent, and which yield their homely product with sure, if moderate returns;

and in the end give a much steadier prosperity than mines of precious metals, in spite of the romantic halo which surrounds these.

Again, the cool mountain heights, cool even in midsummer heats, with their pure air, pure water and beautiful, far-reaching views, all these bring throngs of tourists through the summer months. These leave what is better than money, though this is left also, a breezy contrast with the stir of city life, and a contact with men having other aims and ambitions in life than their own. Though summer resorts are not usually ranked among the economic resources of a country, yet the factors which make up a desirable and healthful resort are quite as much dependent upon geological elements as are mines of the precious, or of the baser metals. These elements are abundant in Ulster county, as the numerous great hotels among the Catskills, and the less pretentious, but almost equally attractive, mountains of the Shawangunk range amply testify.

Returning from this excusable digression it is to the nonmetallic rocks and earths that Ulster county must probably look for additions to her wealth from geological sources. These occupy no mean position, even when compared with other States of the Union. The beds of hydraulic limestone yield a cement which is known and used in nearly, if not quite, every State of the country. These alone give rise to a great and growing industry. Hardly second in importance are the quarries of blue stone, which yield a very useful product, finding a ready market in nearly all of the cities of the east. The clay deposits also nourish a great industry. The life of this industry, at the present rate of consumption, appears to be of necessity shorter than the first-named industries, but years must elapse before the clays are exhausted, even if new deposits are not found. The grits of the Shawangunk mountains yield an excellent millstone, but unfortunately this industry seems to be unavoidably on the wane.

There are almost inexhaustible beds of pure limestone, capable of furnishing an excellent lime, but this product receives but little attention. This same limestone, however, crushed into road metal, provides an excellent material for the construction of good roads, of which Ulster county is in sore need. In the following tables the statistics of the economic productions of the county will be found.*

So far as the writer knows the natural gas excitement has not flourished extensively in the county. No wells have been sunk. In the neighboring county, Greene, a gas well was drilled in the vicinity of Cairo. This town is about twenty miles from Phœnicia, and is 610 feet above tide. The drilling of the well was stopped in November, 1886, at a depth of 2200 feet. Salt water was struck at 610 feet, which rose 300 feet in the well in twenty-six hours.

The drill was stopped on account of losing the tools. The rock passed through was shale and sandstone. The hardest stratum was a gray sandstone lying between 1590 and 1610 feet. This stone was so hard that the drillers reported it to be granite.

"The dip of the strata in the vicinity of the Cairo well precludes the existence of natural gas in commercial quantities. In the vicinity of the well the strata dip north† sixty-seven degrees west, 185 feet to the mile. This is the minimum dip in this part of Greene county. The dip of the Corniferous limestone, where it outcrops at the town of Leeds, along the Catskill creek, is 1120 feet to the mile; the average dip from this outcrop at Leeds to the Cairo well is 580 feet to the mile. Although gas in commercial quantities may be found in eastern New York, I have no hesitancy in asserting that it can not be found in the region between Kingston, Catskill village and the Cairo well."‡

In the opinion of the above writer natural gas and petroleum seem to be a very doubtful product in Ulster county. In any case drill holes sunk for this product are very expensive, and they should not be undertaken without a thorough knowledge of the local geology.

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* In preparing these statistics the writer is under great obligations to the citizens of Ulster county. He has met with uniform and intelligent courtesy, and it is with sincere pleasure that he tenders his thanks for it. It will be useless to mention all by name, but to the following gentlemen he is indebted for special favors: Mr S. D. Coykendall, Hon. Jas. G. Lindsley, Mr Hewitt Boice, Rogers and Tappan, of Kingston, Mr. Louis Bevier, of Marbletown, Mr. B. Taylor Harris, of Saugerties.

† Probably a typographical error for *south* — H.

‡ Petroleum and Natural Gas in New York State. Paper read before A. I. M. E., Duluth meeting, July, 1887, revised to June, 1888, by Chas. A. Ashburner, M. S., C. E.

The following table will show the range and distribution of the economic geological products of this county:

Geologic Age.		Material.	Uses.
Upper Silurian..	Oneida.....	Shawangunk grits............	Millstones. Chasers. Chaser pavements. Glass sand.
	Salina......	Waterlime	Rosendale, or natural cement stone.
	Lower Helderberg ..	Pentamerus limestone .... Tentaculite limestone.........	Lime, and road metal.
Devonian.	Upper Helderberg ..	Corniferous limestone........	Building stone. Road metal. Lime.
	Hamilton ..	Hamilton flags	Flagstones, curbs, posts, lintels, sills, water tables, etc.
	Catskill.....	Catskill flags and sandstone...	Flagstones, curbs, etc., dimension stone.
Quaternary		Clays........................	Building bricks, etc.
		Sands	Building sands, tamping, bricks, cements, etc.

The following list shows the number of men employed in the three principal industries of the county:

Total number of men employed in the cement industry,	1,828
Total number of men employed in the blue stone industry	1,382
Total number of men employed in brickmaking.......	1,270
Number of men employed in getting out millstones, road metal, burning lime, quarrying limestone, etc. (estimated)	520
Total number of men	5,000

It is not probable that this is the average through the year, but the figures are estimated to represent the highest number employed at any one season. In brickmaking the greater part of the men are employed from, and including, May to October.

In the winter only a very few are employed in hauling bricks, care of buildings, etc. In the blue stone industry the greater number of the men are employed during the summer, thus working only a part of the year. Many farmers, who occasionally quarry blue stone, work only a few weeks or months out of the year. The cement industry, however, keeps its men pretty constantly employed. The scattering industries, lime burning, etc., are irregular.

Rosendale, or Natural Cement.

In the manufacture of natural cement Ulster county leads all other localities, as the following table from "Mineral Resources of the United States, U. S. Geological Survey," 1890, will show. According to this table —

	Barrels.
Rosendale (Ulster Co.) produced in 1891	2,815,010
Louisville, Kentucky	1,501,200
Buffalo and Akron, New York	745,450
Lehigh Valley, Pennsylvania	520,000
Milwaukee, Wisconsin	425,000
Utica and La Salle, Illinois	450,000
Potomac River	250,000
Fort Scott, Kansas	140,000
Mankato, Minnesota	101,875
Onondaga and Schoharie counties, New York	215,000
Virginia, Georgia, Texas, Ohio, Missouri and New Mexico	218,000
Total number of barrels produced in the U. S. in 1891	7,451,535

It will thus be seen that Ulster county produced nearly thirty-eight per cent of the natural cement made in the United States in 1891.

In accounting for this great industry it is not sufficient to say that the natural composition of the hydraulic limestone of this county is superior to all other localities; or that the greater thickness of the beds, or the position in which they lie, render the mining of the rock much cheaper. The following table,*

* William Allen Smith is the author of the chapter on cement from which this table is copied.

copied from "The Mineral Industry," R. P. Rothwell, E. M., editor, shows the composition of the hydraulic limestones of the United States:

	Ulster Co Rosendale.	Ulster Co. Rosendale Light.	Utica, Ill.	Milwaukee, Wis.	Fort Scott, Kan.	Cement, Georgia	Sigfried, Pa	Coplay, Pa.
Carbonate of lime	45.91	50.82	42.25	45.54	65.21	43.50	78.92	67.14
Carbonate of magnesia	2[illegible].14	17.74	31.98	32.46	10.65	22.00	2 66	2.90
Silica and insoluble.	15.37	22.66	21.[illegible]2	17.56	15.21	22.10	1[illegible].62	18.34
Sesquioxide of iron and alumnia	11.38	2.39	1.12	4.44	4.[illegible]6	7.25	6.25	7.49
Sulphate of lime	......	4.37	......	......	......	......	......	....
Oxide of manganese	......	0.55	......	......	......	......	......	....
Potash and soda	......	Traces	......	......	......	0.22	......	0.19
Organic matter	....	0.99	......	....	.....	....	......	....
Water and undetermined	1.20	0.4[illegible]	3.53	4.37	4.95	0.55	......	3.94

While the above analyses show a rather wide range in chemical composition, one fact stands out clearly that a natural cement rock is essentially a magnesian limestone with a rather high percentage of silica and alumnia. It is also quite probable that a given cement rock bed in one locality, if properly mixed throughout in the process of manufacture, is quite as good as that from another. We must, therefore, look to other sources for the extended use of the Rosendale cement, as the eastern natural cements are generally known. First of all will come the experience of the makers.

The property of "hydraulicity" was first discovered by a French engineer named Vicat in 1818. Fourteen years after this discovery, or in 1832, the first Rosendale cement was made in Ulster county, New York. From that date until the present time there has been a constant increase of the output of the Rosendale cement. In 1882, according to the "Mineral Resources of the United States," the Ulster county output was 1,600,000 barrels of 300 pounds net. From this date (1882) to 1892 a constant increase is shown: 1882, 1,600,000 bbls.; 1889, 2,547,225; 1890, 2,683,579; 1891, 2,815,010; 1892, 2,8 3,107. The total product of 1893 is not given, as when the statistics were taken the year's output had not been summed up. The accompanying table gives the estimated manufacture.

It is very evident, however, that an experience of sixty-one years in the manufacture of cement goes a long way in explaining the confidence which engineers have in the Ulster county cements.

Another factor aiding in the development of this industry is the fact that these cement mines are in the center of an energetic manufacturing and engineering county. A third factor is the transportation facilities. The mines which produce the rock, the kilns for burning, and the mills for grinding are so situated that coal is brought to them by water via the Delaware and Hudson Canal, and this canal, the Walkill and the Hudson river, the West Shore and Walkill Valley railroads receive the cement direct from the mills without cartage in most cases. These facilities minimize the cost of production. The rock which is mined for the manufacture of cement belongs to the upper part of the Salina or salt-producing formation, though the salt-bearing beds do not occur in the eastern part of the State. Throughout the cement region a division is recognized into an upper and a lower cement bed. At Rondout, in the mines of the Newark Lime and Cement Company, these two beds, according to Hon. Jas. G. Lindsley, are in direct contact. In all the other localities where the rock is mined the "upper cement bed" is separated by about twelve feet of sandy rock from the "lower cement bed." These beds are nearly equal in thickness, varying from seven to twenty-four feet. The lower cement bed is usually the thicker of the two, where there is a difference.

The cement beds are overlaid by thin-bedded, dark colored Tentaculite limestone, followed above by heavier and very nearly pure limestone, known as the Pentamerus limestone. (See cut of New York and Rosendale Cement Company's mine at Rosendale.) Fossils are very rarely found in the cement beds, though abundant in the limestones immediately overlying them.

The workable beds of cement rock are found principally north of the Walkill and Rondout creek. At High Falls the Shawangunk grit appears, and from this point southeast of Rondout creek it rises in high mountain ridges, extending to Ellenville and further. The cement rock is thus cut off in this direction, while to the northwest, though limestone outcrops at Napanoch and several other localities, the cement rock has not been observed. Across the valley (to the northwest) the Devonian rocks appear in high hills. It is thus evident that the cement beds are deeply buried.

The same appears to be true to the north and northwest of Kingston. To the west of Saugerties the Cauda-galli and Schoharie grits appear overlaid by the Corniferous limestone, and these, about four miles west of Saugerties at Quarryville, by the Hamilton group.

It will thus be seen that in Ulster county the present available localities for cement rock are quite preempted. Beginning near East Kingston the cement rock shows on the east face of a steep escarpment. This outcrop can be almost continuously traced to the Newark Lime and Cement Company's mines. From this point south the city of Rondout covers the ground, but at Wilbur the rock appears and is mined at numerous places along the river to Rosendale. In this region the general dip is to the northwest. Beginning at Rosendale and following the line of the Walkill Valley railroad toward Kingston cement rock is found on either side of the road. On the right, going to Kingston, the dip is generally steeply southeast, while on the left, going to Kingston, the dip, at Binnewater, is to the northwest. (See cut of Newark and Rosendale mines; also Lawrenceville Cement Company's mines.)

From this statement it will appear that in the tongue of land lying between the river and the railroad the cement beds lie in a synclinal trough, and that the railroad runs on the broken and eroded anticlinal which formerly joined the two beds. From Rosendale to High Falls there are numerous cement mines, all on the northwest side of Rondout creek. At High Falls, however, the cement beds lie on the southeast bank. The probability that the cement beds, referred to as lying between the Walkill and the railroad, lie in a synclinal trough is intensified by the fact that the Cauda-galli grits occur in heavy beds in Rondout west of the cement mines, and that the Corniferous limestones overlying them occur farther west and a little east of the West Shore railroad station at Kingston. Although the cement rock thus lies in a synclinal trough, it is by no means a simple fold. The rocks are subjected to the most violent crushing and folding. In the Newark company's quarry at Rondout the outcrop is nearly vertical. This is succeeded, in the mines, by a flattening and then by a steep dip to the northwest. Abrupt folds are also to be observed in the mines between Binnewater and Whiteport. It is thus probable that the cement rock even in this tongue of land is almost inexhaustible. The only question is, can it be won with

PLATE 2.

Lawrenceville Cement Company's Mine, Fifth Binnewater, Ulster County, N. Y. The Upper Cement Bed has been tripped Off. Looking Northwest.

profit in the future? The answer to this question depends upon the amount of water encountered, and upon the uniformity of the slope. The mines at Rondout are already about 100 feet below the level of the Hudson, and at Rosendale several mines are from 100 to 150 feet below the level of the Walkill. In none of the mines as yet have large volumes of water been thus far encountered. The water is much less than in the iron mines of New Jersey.

With increasing depth, if the slope continues tolerably uniform and regular, a winding engine on the surface can haul the rock to the surface for a great distance. At the Hurdtown mine in New Jersey, for example, the ore is hauled up a slope of about thirty degrees, for a distance of about 4500 feet. Here the slope is very regular. If, however, large rolls or irregularities should be met with, these would have either to be drifted through or a separate winding engine would have to be put in, which would materially increase the cost of mining the rock.

The roof of the mines appears to be very strong, and after the mines are carried far enough underground to be free from the action of frost, rock-falls seldom occur.

In this report the worked cement beds have been referred to as mines instead of quarries. Except in one locality the quarry of Mr. Jos. H. Vandemark, at Bruceville, just below High Falls, all the cement rock is won underground. At Mr. Vandemark's quarry a face 420 feet long is worked. The bed at this point is about thirty feet thick. A shaly limestone, eight feet thick, has to be stripped from the bed. Other localities at High Falls have hitherto been worked as open-cut quarries, but the stripping has become so heavy that mining operations have begun.

At Binnewater the Lawrenceville Cement Company has just begun mining on a bed about twenty-four feet thick. There is a possible working face over 800 feet long. Their mines at Lawrenceville have been abandoned for the present. The accompanying cut from a photograph shows the method of operation. A modification of the pillar and stoll method is used in all of the mines. The mines are all worked on the slope, no shafts having as yet been sunk. As a rule the head of slope is either about on the level with or a little higher than the top of the kilns. The rock is broken in the mines to kiln size. It is then hauled up the slope and trammed to the kilns and dumped in. After burning, the stone is drawn from the kilns and trammed to the mills, ground and barrelled. It is then taken to stock-houses and is ready for shipment.

Practically the cement beds of Ulster county seem inexhaustible, and from their favorable location and facilities for handling and shipment it would appear that no locality can expect to make natural cement more cheaply.

There have been several attempts to manufacture Portland cement here, but none have succeeded in producing it cheaply enough to compete with the natural cement, though it was superior in quality. Mr. S. D. Coykendal, who is largely interested in the New York and Rosendale Cement Company, informed me that after the expenditure of $50,000 in the attempt he had come to the conclusion that Portland cement could not be made to compete with the Rosendale.

Blue Stone.

The range of the workable blue stone extends from Albany county through Greene, Ulster, Delaware and Sullivan counties, New York, into New Jersey and Pennsylvania. In New York State Ulster county is by far the largest producer. Quarried over a large area the stone is concentrated at the tide water shipping points on the Hudson river, at Malden, Saugerties, Glasco, East Kingston, Rondout and Wilbur.

The product reaches these points in three ways. First, a small proportion is delivered to the Delaware and Hudson canal above High Falls; second, it is hauled by wagon to Wilbur, Rondout, Kingston and East Kingston, Glasco, Saugerties and Malden; third, a large per cent of the total is delivered at Rondout by the Ulster and Delaware railroad. In the township of Saugerties the quarrying industry centers at Quarryville, West Saugerties and High Woods; in the township of Kingston, at Dutch Settlement, Hallihan Hill, Jockey Hill, Dutch Hill, and Stony Hollow; in Hurley township, Bristol Hill, Morgan Hill, Steenykill and West Hurley; in Marbletown, at Woodstock, Brodhead's Bridge, Shokan, Boiceville, Phœnicia, Woodland Hollow, Fox Hollow, Shandaken, Pine Hill, Rochester, Wawarsing, and near Ellenville blue stone is also produced. The ranges producing the blue stone may be roughly divided into two parts: first, the low range

Fig 1. Showing possible faulted structure

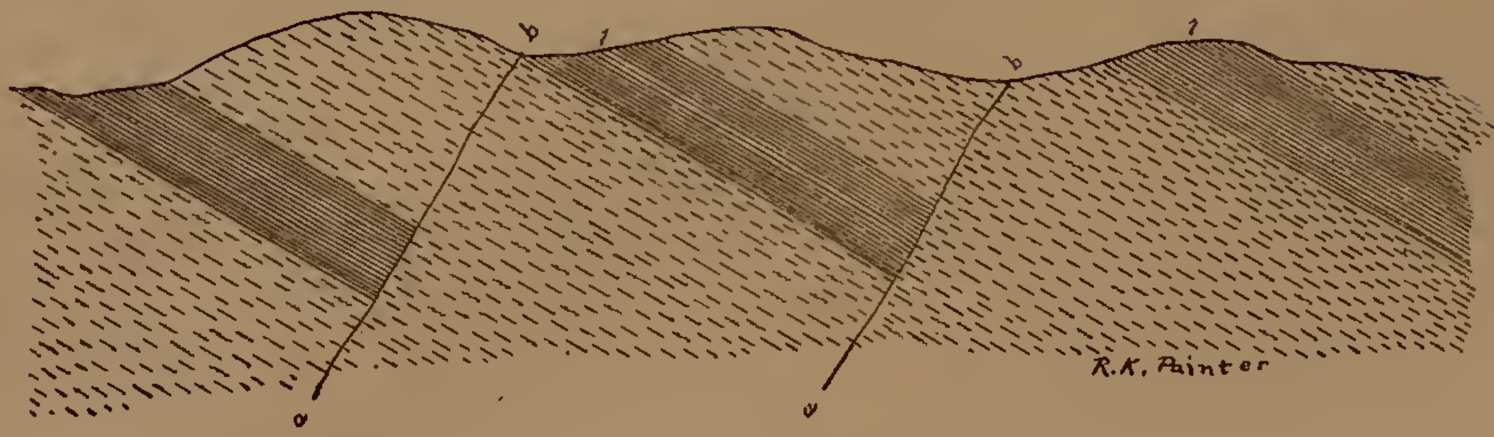
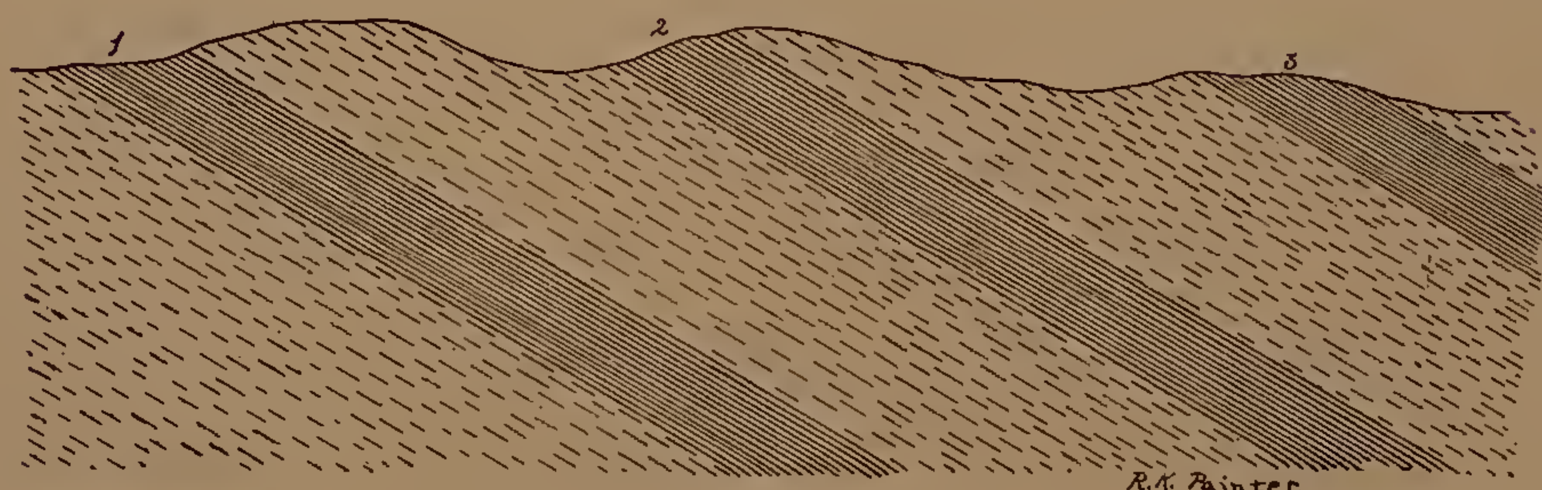
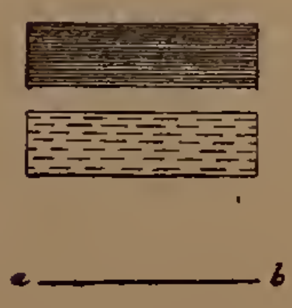


Fig 2. Showing possible occurrence of successive beds without faulting





Workable blue stone.

Argillaceous gritty slates.

Possible fault lines

of foot hills of the Catskills; second, the stone which is produced higher up, both by actual vertical measurement, and also in the geological scale. At least the blue stone produced from the lower range belongs probably to the Hamilton group of the Devonian. These quarries are located at an altitude between 500 and 700 feet above tide water, while it is probable that the quarries farther up the Ulster and Delaware railroad, or at a vertical altitude of from 700 to 2000 feet and upwards belong to the Catskill group of the Devonian. Quarries are worked at Big Indian on the Ulster and Delaware railroad. This station is about 1200 feet A. T., and quarries are worked on the hillside 100 to 500 feet above this point.

The following elevations of points on the Ulster and Delaware railroad are taken from Van Loon's Catskill Mountain Guide. These stations are the principal points of concentration of the blue stone gathered from the quarries in the vicinity of the railroad. The quarries are distant from the railroad from a quarter of a mile to five miles. West Hurley is the first point west of Kingston where blue stone is quarried. This station is 530 feet A. T., and the tributary quarries, without doubt, belong to the Hamilton formation. Brodhead's Bridge, eight miles west of West Hurly, has an elevation 500 feet A. T. Boiceville is 615 feet A. T., and Mt. Pleasant is 700 feet. From these last two stations the pink and gray sandstones are shipped, together with the blue stone; it is, therefore, probable that the stone comes from two distinct geological horizons. Phœnicia has an elevation of 798 feet; Shandaken, 1060 feet; Allaben, 990 feet; Big Indian, 1209 feet, A. T. From Phœnicia nothing but the pink and gray stone is shipped. The quarries here are at varying altitudes above the station. Quarries just south of the track are from 300 to 500 feet higher than the station. Adding this to the height of the station, A. T., we find the altitude of the stone produced here to be from 1100 feet to 1300 feet A. T. The altitudes of the stations are from railroad levels, the altitude of the quarries above the station are estimated.

The principal points of difference between the typical North river blue stone and the stone quarried above Boiceville and Mt. Pleasant are about as follows: first, as to color the North river stone is a dark bluish-gray, the color of the Catskill stone is pink, reddish-brown or greenish gray; second, the North river stone is almost wholly a fine grained, silicious sandstone, with very little argillaceous matter; the Catskill stone has more clayey matter, and is not so compact; third, the North river stone is of a very uniform tint and texture, while the Catskill stone varies between the shades given above, and is not as apt to be constant in its characteristics.

These points of difference, together with the distinct change with change of elevation, appears to make it quite certain that these flagstones belong to two distinct geologic horizons. Prof. Smock, "Building Stones of New York," p. 266, regards all of the quarries above Boiceville as in the Catskill group of rocks.

In each of these groups the workable stone appears under about the same conditions. The whole formation consists broadly of shales and thin-bedded (flagstone) layers and thick-bedded layers of sandstone. In any one group, as for instance the Hamilton, there are several alternating layers or beds of worthless shale and beds of workable stone. The shales consist of very thin argillaceous and sandy layers (the clayey material coming in lenses called *callous* by the quarrymen). The beds of workable sandstone vary in thickness from one inch to two feet. The total thickness of the workable beds varies from four inches to eighteen feet. The thickness of the shaly or slaty beds between the workable beds is unknown, for it is not possible to work a given bed at a profit, if the stripping required exceeds eight to fifteen feet maximum. If the side hill or outcrop in which the workable bed occurs is very steep the bed can be uncovered a distance of from twenty five to one hundred feet, more or less, before the thickness of the overlying slate becomes too great to be removed at a profit.

The entire formation dips at varying but usually gentle angles to the northwest. The quarry faces are thus turned to the east. The quarries have the appearance of being located along the eastern edge of a monoclinal outcrop. In places there are two or three series of quarries parallel to each other. It is not certain whether this appearance is due to a true monoclinal structure, or whether the rocks as a whole have been tilted to the northwest. The accompanying cuts show the two possible interpretations of the structure. Repetition by faulting appears, however, to be the most plausible explanation, though there are

PLATE 3.

Blue-stone Quarries, Quarryville, N. Y. These Quarries are in the Hamilton Group and are about 500′ A. T. Looking Northwest.

probably several workable beds. In some quarries the stripping is very light over a large area. Especially is this true where the dip seems to be very slight, and where erosion has carried away the worthless slates. In this case working is continued until the water becomes troublesome, when the quarry is abandoned. Occasionally hand pumping is resorted to, in other places drainage by siphon is used As a rule, however, no pumping, except for small accumulations after a shower, is resorted to. As will be inferred from former statements, the quarries are nowhere deep. The depth can be given in the following manner: Stripping, four to fifteen feet; workable beds, three to ten feet; depth of quarry, seven to twenty-five feet In working the quarries the following method is pursued. The soil is first removed, generally by barrows. Then, if the quarry be new, the loose slate is stripped and wheeled away and dumped opposite the face of the quarry. The soil and slate are thus stripped down to the bed of workable stone. The length of the stripping is usually twenty to fifty feet. The width, from face back, depends largely on the jointing in the stone, and is from five to twenty feet.

First, after the stripping, there are usually thin flags from one to two inches thick; these are generally saved, though the market for such thin flags is very limited. Then come the heavier and more valuable flags from three to six inches or more thick. These are loosened from the beds by means of gads (thin steel wedges). After loosening these beds, the stone is marked out in such sizes as have been ordered. Along the lines marked out are drilled small holes. The stone is then broken by wedges and feathers. After breaking, the stones are trimmed by cutting off the jagged edges and by chipping off any little bunches or irregular surfaces. Heavier pieces of stone, eight to twelve inches thick, are broken in the same way. This dressing in the quarry rapidly litters the floor with spalls and broken fragments. This material is piled up in layers, leaving driving spaces between the piles. There are comparatively few quarries where derricks are used The reasons for this are the initial cost, the expense of setting up and also to the fact that the greater part of the workings are temporary and soon have to be abandoned. Large stone are loaded on wagons by main strength. There are usually two, three or even eight or ten quarries in close proximity, and when an extra large stone is to be moved, a sufficient number of men are summoned from the neighboring quarries to handle it. As only two or three men, on an average, work in each quarry, this changing work is necessary when heavy stones are to be moved. The rough trimming is usually all that the quarrymen attempt. In other words, the quarrymen only roughly dress to size. This rough material is sold to the dealers. It is then taken to mills either at tide water or near railroads, where it is sawn into exact size. For finely-dressed and surfaced stone large planes are used. The saws are such as are used in marble mills that is, strips of soft iron, and the cutting is done by sand fed to the saws by shovels and distributed by streams of water. The planers are built after the same general plan of iron planers. The kinds of stone, as to shape, size and use, are more numerous than the uninitiated would imagine. The principal terms used to designate them are as follows: Flagging, platforms, rock, cut garden, curb, gutter, sills, coping, door sills, steps, Belgian bridge-crossings, rubbed sills, rubbed curbs and lintels, axed twenty-inch curb, rubbed flagging and hearths, planed flagging, planed headers, planed platforms, sawed and planed well stone, foundation stone and corners. All of these vary in size and weight and thickness.

In regard to the ownership of quarries, it may be said that comparatively few of the men engaged in quarrying own the quarries which they work. A farmer on whose farm is workable stone may lease his stone to the quarrymen. The royalty exacted is about five cents per square foot of surface uncovered. For instance, if a quarryman strips a bed of stone 100 feet long by 10 feet wide, he pays royalty in the following way: 100 feet × 10 feet = 1000 square feet, 1000 square feet × .0 = $50 This is independent of the thickness of the bed. The amount of necessary stripping influences the price per superficial foot. When another block is stripped the owner measures it up and is paid his royalty. Another method in vogue is to charge a royalty on the gross sales. A quarryman takes a load of stone to a buyer and receives cash, less two to five per cent, which is paid to the owner of the quarry. Some farmers work a block of stone during the year when a slack time comes; though, as a rule, their workable stone is leased to men who follow quarrying as a steady business.

PLATE 4.

Blue-stone Quarries, Quarryville, Ulster County, N. Y. Upper Michigan Quarry, Hamilton Group, about 500' A. T. Looking Southwest.

Even the larger dealers in blue stone, such as the Ulster Blue Stone Company, Hewitt Boice, Rogers & Tappan, and others, quarry but a small per cent of their stone. The Ulster Blue Stone Company, for instance, owns about 2000 acres of blue stone land in the vicinity of Quarryville. Yet they do not themselves quarry a foot of stone. Their quarries, so far as worked, are leased. At Quarryville a long face of stone is worked, and derricks are put up for the convenient handling of heavy pieces. Active quarrying of the stone is prosecuted for about six to eight months in the year. In the winter months the stripping is done. The ground is then frozen hard, and the slates quite firmly cemented by frost. Dynamite or some other high explosive is used to loosen the rock and dirt. This is found to be better and more economical of time and labor, since the frozen dirt and slate can be handled better than when uncemented. Then, too, this work can be done in cold weather when the cutting would be quite impossible.

As regards the quality of the blue stone the following notes on the microscopic structure, made by the writer for Prof. Smock's "Building Stones in New York," may be interesting here.

"Blue stone, Bigelow Blue Stone Company (now Ulster Blue Stone Company). Minerals: quartz and feldspar. The quartz is in grains, which appear to be very angular in shape, more like a breccia. The grains are clearer than those of other sandstones examined, and the proportion of quartz grains to the rest of the matter is smaller. The feldspar observed differs very materially from that in the other stone. Grains of triclinic feldspar are observed, which are very fresh. Another feldspar is almost completely decomposed. No carbonate of lime appears to be present, and very little oxide of iron. The long, wavy, crystal-like dark spots in the stone appear to be decomposed feldspar, more or less stained with iron. The cementing material is probably silica, as dilute hydrochloric acid has no effect, and it is not stained with iron." *

A chemical analysis by Prof. Wilbur (ibid.) showed 4.62 per cent of ferrous oxide. On heating the stone to the melting point of

* The test was as follows: A thin slice of the stone one one-hundredth of an inch thick was immersed in the dilute acid. In the case of a calcareous sandstone, or of a ferruginous sandstone, the grains of silica and feldspar would have been loosened into sand. The slice of rock remained practically unaffected.

copper in the air and cooling, the color was changed to a dull red. The color of the stone is thus due partly to ferrous oxide of iron and partly to organic matter. The complete series of tests made by Prof. Wilbur gave the following results: "Specific gravity, 2.751; weight per cubic foot, 171 pounds, ferrous oxide, 4.63 per cent; ferric oxide, 0.79 per cent; water absorbed, 0.82 per cent; loss in dilute sulphuric acid, 0.20 per cent; alternate freezing and thawing unchanged; at a temperature of 1200°–1400° F., color changed to a dull red, slightly checked and strength somewhat impaired."*

The prevailing color of the stone is a dark or bluish gray. There is some reddish colored stone, and even stone of a greenish color is found. The preference, however, is for the typical blue stone. The typical blue stone is probably that which comes from the Hamilton group, while the reddish or greenish-colored stone comes from the Catskill series. In texture the stone varies from the exceedingly fine-grained material which takes a very even finish, to a sandstone which is almost conglomeratic in its nature. As may be inferred the finer-grained material is much stronger.

There is but a small admixture of argillaceous or clayey matter and the cementing material is almost wholly silica. This insures the durability of the stone, since silica is practically unaffected by the exposures which ultimately tell on limestones, marbles, granites and on calcareous and ferruginous sandstones.

The stone is so compact as to absorb but little moisture, and thus when used as flagging rain or ice remains upon it but a short time. Its hardness resists wear and it always wears slightly rough, never forming the slippery surfaces of clay slate. The demand for the stone seems to be continually increasing.

In view of this last statement, inquiry may be made as to the condition of the source of supply. In answer it may be said that the field is practically inexhaustible. At present only the most accessible points are worked. With the improvement of roads and the increased demand for stone still other quarries will be opened. In the Catskills, along the line of the Ulster

* "Building Stones in New York," by J. C. Smock, Bulletin New York State Museum, vol. 2, No. 10, 1890.

PLATE 5.

Blue-stone Quarries, Quarryville, Ulster County, N. Y. Lower Michigan Quarry, Hamilton Group; about 500′ A. T. Looking Northwest.

and Delaware and the Stony Clove railroads only the lower tier of outcrops is now worked. If necessity arises the higher tiers or layers of stone, which are quite inaccessible by roads, can be worked by building slides from the quarries to the foot of the steep inclines. At present, however, and for a long time to come this step will be unnecessary.

The three accompanying plates, from photographs of the range of quarries at Quarryville, are typical of the larger and best managed quarries. These quarries are, however, as has already been stated, worked on the block system of rental, two to four men working in company on a block.

The following list of quarrymen was obtained from buyers at the stations on the Ulster and Delaware railroad, or from dealers at tide water. This information was obtained from George W. Lament, Big Indian; A. M. Loughsdyke, High Falls; Rogers & Tappan, Wilbur; Hewitt Boice, Rondout; B. Taylor Harris, Saugerties; E. Risley, Allaben; J. L. McGrath, Phœnicia; John Boice, Brodhead's Bridge; John Winne, Mt. Pleasant; James O'Neil, West Hurley; E. O. Roarke, West Saugerties.

Brick Manufacture.

The importance of this industry may be seen by a glance at the accompanying table. Even during the business depression of this year (1893) 152,000,000 of bricks have been made. During the past year none of the yards have run to their full capacity.

The quality of the North river bricks are too well known to need any discussion of that point in these pages. None of the manufacturers have made anything but the common building bricks, but there is nothing in the quality of the clays to prevent the making of the finer grades of pressed brick.

Like all of the brickyards along the Hudson river, the shipping facilities are unexcelled. The clay banks lie along the margin of the river. The yards are so situated that the clay can be carted to the machines, from the machines to the drying yards, then to the kilns and thence into boats or barges which can tie up within a few feet of the kilns. Fuel can also be brought to the yards entirely by water. Thus every facility exists for cheap making and shipping.

The brickyards are located at Malden, Glasco, East Kingston, Kingston and Port Ewen.

The clays are of two kinds, the blue and yellow. The blue clays are the lowest, nearly every outcrop of blue clay being covered by a mantle of stratified yellow clay. These rest either upon cross-bedded glacial sands or directly upon the rocks, usually of the Hudson River group.

Little in addition to Mr. Heinrich Ries' work in the local descriptions of individual claybanks or upon the deposits of the quaternary in the Hudson River valley need be given here. The work has been done excellently and for this the reader is referred to the tenth annual report of the State Geologist for 1890, page 110 *et seq.* What can be done is to call attention to the probable extension of this formation into the interior of the county.

At Wilbur, on Rondout creek, one mile above Rondout, are immense sandbanks at least one hundred feet high. The sand here is well stratified, and lies in alternate beds or lenses of varying degrees of fineness. There are large quantities of this sand removed every year, and used principally in tempering bricks in the yards above Rondout. The excavation is made in a V-shaped cut so that the sand is constantly running in from the top. The cut in the deepest part is yet at least twenty-five feet above the level of the river. It seems very probable that these sands overlie deposits of clay, but no trace of it is to be seen. Farther up the stream, near the West Shore railroad bridge, rocks come to the edge of the river. From this point up there is no chance for either sand or clay deposits to exist except in a few depressions of limited extent. One pocket of this kind is well exposed at Le Fever Falls. This point is a little more than eight miles from Kingston on Rondout creek. The deposit is fat yellow clay well stratified, about ten feet thick and about thirty feet wide where worked. It is covered with well stratified sand and light gravels. Judging from the contour of the country this deposit must cover a good many acres. The clay rests on the Cauda-galli grit. The altitude of this point is not known but it must be considerably over 300 feet.

No other deposit has been observed, but along the valleys of the Rondout and of the Walkill rivers there are large banks of well stratified sands. There are, no doubt, many places where clays have been deposited to a greater or less extent. Just at present, however, these additional deposits are not needed for anything more than local use. Their distance from transportation facilities would preclude competition with deposits along the tide waters of the Hudson.

Millstones.

Three States in the Union produce these stones, New York, Pennsylvania and Virginia. In this production, however, there has been a steady decrease since 1883. In this year the above-named States produced stones to the value of $150,000. In 1890 this was reduced to $23,720.

The reason for this great decrease can be ascribed entirely to the general adoption of the roller process in flour mills. The use of buhrstones is now almost wholly confined to the grinding of cement, paint, gypsum, etc.

The French buhrstone is said to be superior to the American by men who grind gypsum, baryta, etc., as it is tougher and wears longer.

The Shawangunk grit, from which the Ulster county millstone is quarried, is a light gray quartz conglomerate. The quartz pebbles are usually of a milky white color. They vary in size from that of a small pea up to that of a butternut. The matrix is a gritty silicious paste.

The grits, beginning at High Falls, extend in gradually increasing height to Ellenville and into Pennsylvania. The grits occur in beds of varying thickness. They are of the same general character throughout the entire length of the county.

The method of quarrying the stone is very simple. A large block of stone is separated by means of its natural lines of bedding and jointing. It is then roughly shaped by means of wedges, holes being drilled and wedges driven in. The stone is then dressed into shape.

The rock lies very near the surface along the line of the Delaware and Hudson canal, being covered generally by only six inches to one foot of grit. It is along the line of this canal that the greater part of the stones are dressed and shipped. Kerhonkson and Kyserike are the two principal points of shipment. From these two points are shipped about 350 tons a year. These figures include the stone that is carted to Rosendale station on the Wallkill Valley railroad.

The millstones vary in size and thus greatly in price. For milling, stones are quarried from fifteen inches to seven feet in diameter. The smaller stones vary in price from $5 to $15, while the seven-foot stones from $50 to $100. The millstones are used for grinding, chasers for crushing. Blocks twelve by twelve by ten inches are used for paving the chaser floors. These and the chasers are used in quartz and feldspar mills, principally for preparing these materials for potters' use.

At Ellenville this stone is quarried for glassmaking by the Crystal Glass and Manufacturing Company. They quarry 800 tons per year. The stone is crushed and ground at Ellenville and shipped to glass companies in Pennsylvania and at Port Jervis, N. Y.

Steam power is used at the crushing mill.

Road Metal.

The rocks available for this purpose in Ulster county differ in no respect from those in Albany county. The geologic horizons are practically identical, save that the cement and flagstones are better developed. In the city of Rondout the Cauda-galli grit is well exposed on Hasbrouck avenue. Just east of the West Shore railroad station, on the line of the electric car tracks, are large outcrops of the Corniferous limestone. Both of these outcrops have been worked for road metal.

In regard to the use of the Cauda-galli grit, the Hon. James G. Lindsley informed the writer that it had been used to a considerable extent, but its use had been abandoned. The rock, even though it may appear quite solid when first taken out, soon air-checks and breaks into fine angular fragments. When put into roads light travel soon reduces it to a smooth surface and a tolerably compact bed. For heavy traffic the material is of inferior value and its use as a road metal has practically been discontinued.

The Corniferous limestone before referred to is being worked to some extent. Mr. Thomas Lynch, of Kingston, has a stone crusher, with steam for power drills. He crushes eighty tons of stone a day for two months per year. He employs twelve men. The stone is used for macadamizing the roads in the vicinity of Kingston.

Mr. Lindsley also supplies some metal from the refuse of the cement mines. The amount is very small. In the vicinity of Kingston, Rondout and Saugerties there are extensive outcrops of limestone, which could supply road metal cheaply and in unlimited quantities, but little use is made of them. The corporation of Saugerties owns a steam-crushing plant near the West Shore railroad track. The material is used for repairing the roads in the village limits.

The principal output of the flagstone quarries of the Catskills and its foothills is hauled to tide water at Kingston, Malden, Saugerties and Wilbur. For this purpose heavy wagons, having two, three and four horses or mules, are used. These wagons, loaded, often weigh from four to seven tons. About three-inch tires are used. As will be readily imagined, these heavy loads, passing almost constantly, have necessitated a substitute for the ordinary dirt roads. Planks have long since been discarded and a simple but expensive and unsatisfactory substitute has been found in the Belgian blocks.

These roads are locally known as "trams." To make the roads the roadbed is first roughly leveled. Then blocks of flagstones about three feet in length, eight inches to one foot in width, and six to eight inches thick, are laid end to end and in parallel rows. They are placed near enough together so that the wheels run over them. With the heavy traffic these stones are soon cut into deep ruts, and in a short time are cut quite through. The road is double, the tram being used by the loaded wagons, and the untrammed road being the ordinary dirt road.

Even were the refuse from the flagstone quarries crushed into road metal, and the roads built in the best manner matters would be little improved. Sandstone of any kind is wholly unfit for the purpose. The best stone for all around use is crushed trap or greenstone, next come fine-grained granites. Gneiss is often used, but, from its liability to split, it is undesirable. Fine-grained, compact, heavy-bedded limestone is nearly as good as trap and granite, but it is, of course, much softer and consequently wears more rapidly even with moderately heavy traffic. Trap and granite are out of the question for road construction in Ulster county on account of distance, but, as has already been stated, there is an abundance of limestone, some of it of excellent quality, and the cost of macadamizing the roads is thus reduced to a minimum. When people once become acquainted with the immense saving by means of good roads the first cost of construction will no longer be considered as an obstacle to their adoption.

Lime Burning.

There is but little lime burned in the county and that principally for local consumption. At Napanoch there is one lime-kiln which supplies the paper-mill with lime.

Two kilns at Wawarsing supply lime for tanneries in the immediate vicinity. A good deal of lime from the above kilns is used for agriculture. At Rochester are four kilns which burn lime principally for agricultural purposes.

Between Marbletown and stone ridge, in the township of Marbletown, are two kilns which burn lime for agricultural use exclusively.

Although the Newark Lime and Cement Company burn no lime, 2000 tons per year of limestone are quarried from the Scutella beds and sent to Newark, N. J., for burning. The limestone burns into a dark-colored lime. The quarries are located at Rondout and the beds overlie the cement rock.

Mr. Frederick M. Goss, of Kingston, has kilns on Hasbrouck avenue and burns lime both for local consumption and for shipment to New York. He usually burns and sells 25,000 to 35,000 barrels of lime per year. Owing to the business prostration this year almost nothing has been done by him.

Water Power.

There are several large streams in this county which are capable of furnishing a great deal of water power. While at a few places this possible power is utilized, the greater part of it goes to waste. The streams capable of supplying large water power are the Rondout and Wallkill rivers, Marbletown and Esopus creeks. Sandberg creek at Ellenville, Beerkill and Fountainkill are smaller tributary streams. At High Falls and LeFever Falls water power is used in some of the cement mills, but neither the full height nor volume of water is used.

There are many smaller tributary streams upon which are situated small grist-mills for local work, and some small saw-mills. In the main, however, the water power is unimproved. It may be well to call attention to the fact that many of the streams are so situated as to render it possible to build large storage reservoirs upon which to draw during seasons of drouth.

Metallic Ores.

At the present date there is not a pound of metalliferous ore mined in this county. In the past, however, there has been great excitement over the lead mines at Ellenville. The mine, which is situated just east of the railroad station and at the foot of the mountain, has produced both galenite, chalcopyrite and rutile. Quartz crystals, many of them of great size and beauty, were also found. In fact, some of the most beautiful clusters of crystals in the mineral cabinets of the world are from this locality.

None of the minerals produced at the mine were, however, of any economic value save the galenite and chalcopyrite.

The mine was first opened in 1851 and was worked intermittently until about 1861. Since this date the water has been frequently pumped from the mine and some exploring work done. The prospects have not been promisir g and the mine has probably now been permanently abandoned.

The locus of the mine mineral vein is a fault fissure which crosses the Shawangunk mountains in a mostly east and west line. The fissure is from five to eight feet in width. It is not wholly an open fissure for this distance, but is more or less completely filled with angular fragments and with slabs of the hard gravel or gritstone. The interstitial spaces are more or less completely filled with interlocking quartz crystals, and in these spaces also are the crystals and grains of lead and copper ore. In the mining operations large cavities, of brilliant beauty, were often found. The walls of the cavern were too far apart to entirely fill with interlocking crystals, but either wall would be thickly studded by clusters of crystals of various size and sparkling brilliancy. Scattered over these were large crystals of galena, chalcopyrite, rutile and brookite.

The vein is nearly vertical. The deepest working is about seventy-five feet, and it has been explored underground about 150 feet along its strike.

The rock or gangue was exceedingly hard and tough. This, combined with the leanness of the ore and consequent necessity for concentration, and the pumping of large volumes of water, rendered the working unprofitable and it has been abandoned for a good many years.

IRON.

Iron ores have been mined to some extent in the valley of Rondout creek near Napanoch. The ores were brown hematite or limonite. No work has been done there for forty years. At that period there was a small forge which made blooms. The principal part of the ore used was magnetite brought from the mines of New Jersey and southeastern New York. The brown hematites were used as mixtures.

There is little prospect of limonite being found in quantities sufficient to pay for working. Magnetite ores are not to be expected, as there are no rocks in which such ores occur.

THE SO-CALLED "COAL AND LEAD REGIONS."

In the western part of the county, two areas with rather indefinite boundaries are known, the one as the "coal region," the other as the "lead region." For the use of these terms there is slight reason. In the western part of the county the Catskill group of rocks is dominant. In these rocks are often found fragments of fossil coal plants and sometimes traces of anthracite coal. This has led to the belief that coal existed in this section, hence the name. Of course no abundance of coal appeared on the surface, but was supposed to exist abundantly "deeper down." The fact that these rocks are all below the horizon of the coal-producing strata should be a sufficient answer to this supposition. In the numerous cracks and checks in the silicious rocks in the same region are oftentimes found traces of galena and zinc blendes. The opening of lead mines at Ellenville and Wurtsboro lent an exaggerated significance to these finds. With the failure of the above-named mines, the excitement has died away, but the name "lead region" remains.

Respectfully yours.

F. L. NASON.

ROSENDALE CEMENT, ULSTER COUNTY, N. Y.

MANUFACTURERS.	Location of mines.	Depth to which worked.†	Length of working face.	Thickness of bed.	Men in mines.	Men on surface.	Number of kilns.	Barrels of cement, 1893, estimated.	Barrels of cement, 1892.
		Feet.	*Feet.*	*Feet.*					
Newark Lime and Cement Company	Rondout	250	2,000	25	70	80	21	200,000	243,961
New York and Rosendale Cement Company	Rosendale								
New York and Rosendale Cement Company	Wilbur	Wilbur 150	Rosen-dale 525	Rosen-dale 33	200	130	7 large 23 small	450,000	403,345
New York and Rosendale Cement Company	Quicklocks	Rosendale 450							
New York and Rosendale Cement Company	East Kingston								
F. O. Norton	High Falls	Open face	300	11	5	50	6	25,000	58,597
High Falls and Binnewater	Binnewater	300	1,320	31	45	100	16	225,000	189,666
D. A Barnhardt	High Falls	Open face	500	32	15	34	9	55,000	61,031
Jas H. Vandemark	Bruceville	Open face	420	20	15	18	4	32,450	53,077
Lawrenceville Cement Company	Binnewater	Open face	800	24	17	79	15	100,000	131,344
New York Cement Company	Le Fever Falls	450	1,000	24	100	100	13	290,000	278,520
Newark and Rosendale	Whiteport	160	4,000	29	55	120	17	155,000	190,210
A. J. Snyder & Son	Lawrenceville	330	150	23	30	80	5	115,000	108,200
Connelly & Shaffer	Quicklocks	300	100	30	55	95	6	135,000	151,952
Lawrence Cement Company	Lawrenceville								771
Lawrence Cement Company	Rock Lock								258,409
Lawrence Cement Company	Eddyville	90 to 1,000	60 to 400	11 to 22	171	165	64	910,056	458,724
Lawrence Cement Company	Esopus*								42,050
Lawrence Cement Company	Binnewater								210,250
									2,833,107

* Kilns only. † Measured on slope.

PRODUCERS OF BLUE STONE, ULSTER COUNTY, N. Y.

	Yards.	Quarries.	Men employed.	Value of feet of stone shipped.
Rogers and Tappan	Wilbur	West Hurly, Marbletown, Beaverkill, Saukill	....	† $300,000
Hewitt Boice	Kingston Rondout	West Hurly	84	† 1,000,000
Ulster Blue Stone Company	Malden	Quarryville	60	51,702
Julius Oshehout	High Falls Wilbur	Marbletown	....	† 230,000
Burhans & Brainard	Saugerties	Quarryville and other places	38	16,000
James T. Maxwell	Saugerties	Quarryville and other places	14	45,000
W. Porter	Saugerties	Quarryville and other places	10	47,000
* E. Sweeney & Son	Wilbur.			

* All information refused. † These are estimated in superficial feet or flagstone measure.

BLUE STONE SHIPPED.

	No. of feet.
Ellenville, quarries four miles west of Ellenville	10,000
Port Bur, quarries west of Port Bur	10,000 to 25,000

PRODUCERS OF MILLSTONES, ULSTER COUNTY.

HANDLERS.	Shipping point.	Blocks.	Mill-stones.	Chasers.
William Vandover	Kerhonkson, D. & H. Canal	12, 1,200 pds. each. 1,000, 12″ x 12″ x 10″	23	29
J. P. Davis	Kerhonkson, D. & H. Canal		40 to 50	12
Van Etten	Kerhonkson, D. & H Canal		50 to 75	
T. C. Harnden	Kyserike. D. & H Canal		136	
David Lawrence	Rosendale, Wallkill Valley Railroad.			

LIST OF QUARRYMEN AND NUMBER OF MEN EMPLOYED BY EACH.

TOWNSHIPS OF SAUGERTIES AND KINGSTON.

Quarryman.	No. of men.
Thomas Lockwood	6
W. Scott	3
James Depew	4
Lewis and Saul York	2
Ed Telter	2
J. Herrick	6
C. P. Loudyke	3
W. T. Brabey	2
Charles Miller	4
Wesley Gunn	5
Charles Gunn	3
Elmer Snyder	2
James Van Aiken	2
Jacob Boose	2
Sanford Conyes	3
Nathan Van Aiken	3
Charles Budd	3
Ed. Laher	4
E. O. Rourke	3
J. Lasher	4
J. Cusick	4
D. Burk	6
John Dongan	6
James Dongan	4
Daniel Dongan	4
J. Layman	3
J. Ferguson	4
John Austin	3
Thomas Carty	4
Patrick Farrel	3
Lannigan & Co	10
Walter Allen	3
J. Scott	3
Ed. Lord	4
Watson Fredenberg	2
Patrick Dunn	2
McCormick & Rhine	3
Daniel Rafferty	3
Eustace Shinick	2
Dennis Sheehan	3
John Floyans	2
Andrew Ruse	3
C. Young	3
George Sheffel	4
A. Vedder	2
Bernard Burns	2
William Lannigan	2
Charles Stauble	3
Patrick Butler	12
Richard Thompson	10
John Murphy	5
Patrick Mannon	4
Thomas Callahan	3
John McCaffrey	4
Lewis Hulser	3
William Bonesteel	4
John Carl	4
David Neenan	2
Welch & Donaldson	7

BIG INDIAN.

Quarryman.	No. of men.	Quarryman.	No. of men.
G. W. Lament	5	Watson Hinckly	3
James Donohue	4	G. N. Tyler	3
B. C. Ducher	8	Heenan Simons	2
Henry Simons	3		

QUARRYMEN IN THE VICINITY OF QUARRYVILLE.

Alphonso Camright.
William Clement.
Newton Craft & Co.
Jesse D. Cook & Co.
Edward Cook.
Hugh Corcoran.
John Coughlan.
Asa Cook.
William Daly.
Owen Devey.
Nicholas Deyo.
George A. Davidson.
John Daly.
Zophan R. Elliott.
Nathan Elliott.
James Farrel.
John Fanning & Co.
Kearn Fowley.
Samuel Freligh & Co.
Myron Fien & Co.
Mrs. John Fitzpatrick.
Morgan Gray.
James Redmond.
C. Harvey & Co.
David Hoff & Co.
Edgar Hommel.
Abram Hommel.
A. Hungerford.
Peter Johnson.
Patrick Kelly.
Frank Lamoreaux.
L. Lamoreaux.
Fred Lasher.
Peter Mack.
Abram Miller.
John Moon & Co.
Zach B. Moore.
Joshua Miller.
John Mower & Co.
James McLaughlin.
Michael McCabe.
John Newbury.
Samuel O'Bryn.
James O'Connor.
John A. Quick.
Wesley Ransome.
John Rourke.
E. Sax & Co.
Emmet Snyder.
John Schoonmaker.
George Valk.
Theodore Van Steenburgh.
William H. Winnie.
James A. Winnie.
James Sterritt.
Christopher Stone.
Abram Snyder.
Orrin Taylor.
William Valk.
William Valkenburgh.
David Waters.
Martin Wasson.

NOTE.— Mr. B. Taylor Harris, president of the Ulster Bluestone Company, kindly gave me the above list. The exact number of men employed by each quarryman was not known to Mr. Harris. He estimates, however, that an average of three and one-half would not be far out of the way.

MOUNT PLEASANT.

	Men.
Nine quarries with	15
Mill and handling stone	9

Quarrymen, Allaben, N. Y.

Quarryman.	No. of men.	Quarryman.	No. of men.
Edmund Riseley	6	Truman Trowbridge	3
Joseph H. Riseley	4	H. J. Newell	3
S. Y. McGregor	3	William Rowe	4
Elias Ashley	3	Edward Rowe	2
Giles Whitney	4	Edward Newell	2
Eli Miller	2	George Rider	3
Somerville & Co	3	Burger & Co	3
Clinton Holden	2	Warren Holden	4
Conlon Byrne	3	Thomas Killian	1
Frank Heaney	1	Walter Evans	1
Alexander Evans	2	George Ennist	3
Gulnick & Peek	2	Hiram Whispell	2
Voter Gildersleeve	3	James Donohue	4
Andrew Finch	2	Crispell & Hornbeck	2
W. S. Post	2	D. B. Crispell	1
Patrick Johnson	2	Dennis Hughes	3
Abram Rider	4	George Resen	1
Ormon Grant	1	Alfred Camright	2

Men employed at station handling stone 10

Quarrymen West of Kingston.

William Gubehens	4	John Ryan	4
Charles Connors	4	W. H. Valleby	3
Edward Brower	5	H. Johnson	4
Hicks & Cudney	3	John Vaughn	5
Sherman Ballard	3	J. J. Winchel	4
John S. Brower	4	Robert Seckler	3
Patrick Mack	3	John Osborn	3
Owen Hickey	3	T. H. Bush	3
L. Carle	3	Fred. Speng	4
John Mearn	3	L. Herrick	5
W. J. Knight	10	E. Maddigan	2
Norman West	4	David Bruce	4
P. W. Ostrander	4	Albert Felter	3
L. Broadhead	3	John Canty	4
George Russell	3	William Warren	5
Henry Miller	3	Isaac Schryver	4
F. Kellyhouse	3		

Quarrymen West of High Falls.*

Jacob McMullen.	C. C. Towner.
Hector Connors.	William Whittaker.
Jacob Hoornbeck.	William Cristrance.
Streeter Rose.	John Hager.
Ira Smith.	Ammon Rose.
Stephen Vandemark.	William Rose.

* Three and one-half men in each quarry on an average.

Quarryman.	No. of men.
George Rose.	
Hugh Palen.	
John Busby.	
George Beesemer.	
Lewis Palen.	
Michael Rieley.	
Joseph Connor.	

Quarrymen Near Brodhead's Bridge.

Mill and dock at railroad station..	10
Asa Barton....	3
William Carson	3
J. R. Beesmer	3
A. Bishop	2
Dewitt Dudrey	2
Eli Rasne	1
Orlando Duylefass	1
Isaac L. Beesmer	2
J. F. Gardner	2
Willis Barton	1
Howard Barton	1
C. O. Winne	3
George Winne	3
M. Reily & Co	5
Carson & Merrihew	4
Willis Van Cleef	3
S. K. Bishop	3
Henry McCleek	3
Martin L. Prospell	2
T. Dewitt	2
Ephraim Markle	2
A. G. Hungerford	3
Michael Hughes	2
Abram Winchell	1
Charles Simmons	1
John Jordan	2
Emery Merrihew	2
Jacob Delamater	2
Henry Davis	2
Herman Barton	2
George Pratt	2
D. Van Leuven	1
Truman Barringer	1
Stephen Van Demark	2
Ephraim Cronk	2
David Smith	2
J. H. Prospell	2
Grant Beesmer	1
Richard Carson	2
Hiram Barton	1
Andrew Harkness	2
William Gunn	2
George Beesmer	2
Egbert Van Kleek	2

Quarrymen, West Hurley.

William Risely (mill and docks)...	8
Hewitt Boice	10
James E. O'Neil	10
Mellin & Co	10
Shader Bros	4
Connors & Co	3
Pierson Bros	5
Piert Bros	3
Colvin Bros	3
Douglas & Son	2
Demond Bros	2
Vaughn & Carey	2
Cahill Bros	2
Van Steenley & Sons	3
Ward Bros	3
Scribner & Crum	2
Wolven & Son	2
Smeedes & Ennist	4
Smeedes & Mack	2
Shader & Co	2
Youngs & Van Bramer	2
McMullin Bros	2
Bahen & Sons	3
P. J. Dunn	7
Dunn & McCann	2
McAuliff & McMan	4
Madden Bros	3
Finnegan Bros	2
Gorman Bros	2
Purcill & Sons	3
Lamb & Son	2
McSperritt	2
Sweeney Bros	2
Urell & Fisher	2
Thomas Grant	10
Mulligan Bros	3

Quarryman.	No. of men.	Quarryman.	No. of men.
George Brower & Son	4	Hiram Kettle	2
Samuel Brower	2	Chase Bros	3
Brower & Ostrander	2	Stoutenburg Bros	3
Alfred Bonesteel	3	Rowe Bros	3
J. D. Brower	3	Abram Van Etten	3
Baher Bros	3	Phillips Bros	2
William Flowers	2	Kelly & Son	2
Devine & Son	2	Bewdond & Buley	2
Hogan Bros	3	William Martle	3
Jones & Son	2	Wolven & Miller	4
Jones Bros	2	David Bruce	1
Charleson & McConnell	2	Eckert & Son	2
Castle Bros	2	Hughes & Van Velsen	2
Fitzpatrick Bros	4	Martin Snyder	2
Connell & Conway	2	Julius Smeedes	3

QUARRYMEN NEAR PHŒNICIA.

J. L. McGrath (dock hands)	8	John Murry	5
J. L. McGrath (quarry)	20	R. Baldwin	3
Thomas Hanley	2	Moore & Co	3
A. M. Whittaker	2	William Merritt	2
E. P. Hilson	2	Bernard Mack	2
R. Burk	2	Peter Neice	3
William Berger	3	M. Roberts	2
Edward Forbes	6	Gemerson Bros	2
William Clancy	3	C. Dyer	2
W. Short	2	Thomas Lavey	2
James McGrath	3	Simpson Bros	6
Lloyd Hill	3	Jesse Elsworth	2

BRICK AND TILE MANUFACTURERS — ULSTER COUNTY, N. Y.

MANUFACTURERS.	Location.	Men employed.	Common brick.	Markets.	Fuel.
Washburn Bros	Glasco	250	25,000,000	New York	Wood and coal.
F. N. Van Duzen	Glasco	70	6,000,000	New York	Coal.
N. Porter	Glasco	....	....	....	
Robert Lent	Glasco	32	3,000,000	New York	Coal.
W. Maginnis & Son	Glasco	60	5,000,000	New York	Coal.
Henry Corse	Glasco	....	Idle in 1893.	....	
Streeter Bros	East Kingston	28	2,000,000	New York	Coal.
A. Rose & Co	East Kingston	40	3,700,000	New York	Coal.
D. C. Overbaugh	East Kingston	40	3,700,000	New York	Coal.
Streeter & Hendrix	East Kingston	50	6,500,000	New York	Coal.
D. S. Manchester	East Kingston	65	6,500,000	New York	Coal.
Brigham Bros	East Kingston	40	5,500,000	New York	Coal.
C. A. Shults	East Kingston	70	8,000,000	New York	Wood.
A. S. Staples	East Kingston	130	17,000,000	New York	Wood.
R. Maine & Co	East Kingston	50	5,500,000	New York	Wood and coal.
Terry Bros	East Kingston	125	12,000,000	New York	Coal.
W. Hutton	East Kingston	135	16,500,000	New York	Coal and wood.
T. Washborn	East Kingston	40	8,500,000	New York	Wood.
S. D. Coykendall	Port Ewen	80	6,000,000	New York	Oil.
J. Klein	Port Ewen	40	3,000,000	New York	Coal.
J. J. Cooney	Malden	25	1,250,000	New York	Wood.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

GEOLOGY OF THE MOHAWK VALLEY

IN

Herkimer, Fulton, Montgomery and Saratoga Counties.

JAMES HALL, STATE GEOLOGIST. | N. H. DARTON, ASSISTANT.

1893.

PLATE 1.

Potsdam Sandstone Overlying Crystalline Rocks on South Bank of the Hudson River at Jessup's Landing, N. Y. Looking South.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Geology of the Mohawk Valley in Herkimer, Fulton, Montgomery and Saratoga Counties.

BY N. H. DARTON.

CONTENTS: STRATIGRAPHY.— *Potsdam sandstone; Calciferous, Birdseye, Black River and Trenton limestones; Utica slate.*

JAMES HALL, *State Geologist:*

SIR.— This report is an account of studies made during the summer of 1893, of the geology of the Mohawk valley in the counties above named. The purpose of the work was to determine the distribution of the formations for the geological map of the State on a scale of five miles to the inch.

STRATIGRAPHY.

Vanuxem has described the stratigraphy of the Mohawk valley at considerable length and I have but little additional data for this region, except as to certain local details. For the region northward there is but little information on record, excepting the stratigraphy of the vicinity of Saratoga Springs; which has been described by Walcott. The Mohawk and Saratoga sections, however, comprise the principal stratigraphic components of the region to which this paper relates. This chapter may be considered a resumé extended somewhat by an account of such details as I have to present. The principal new information is in regard to distribution and the features of notable outcrops which have not before been as fully described.

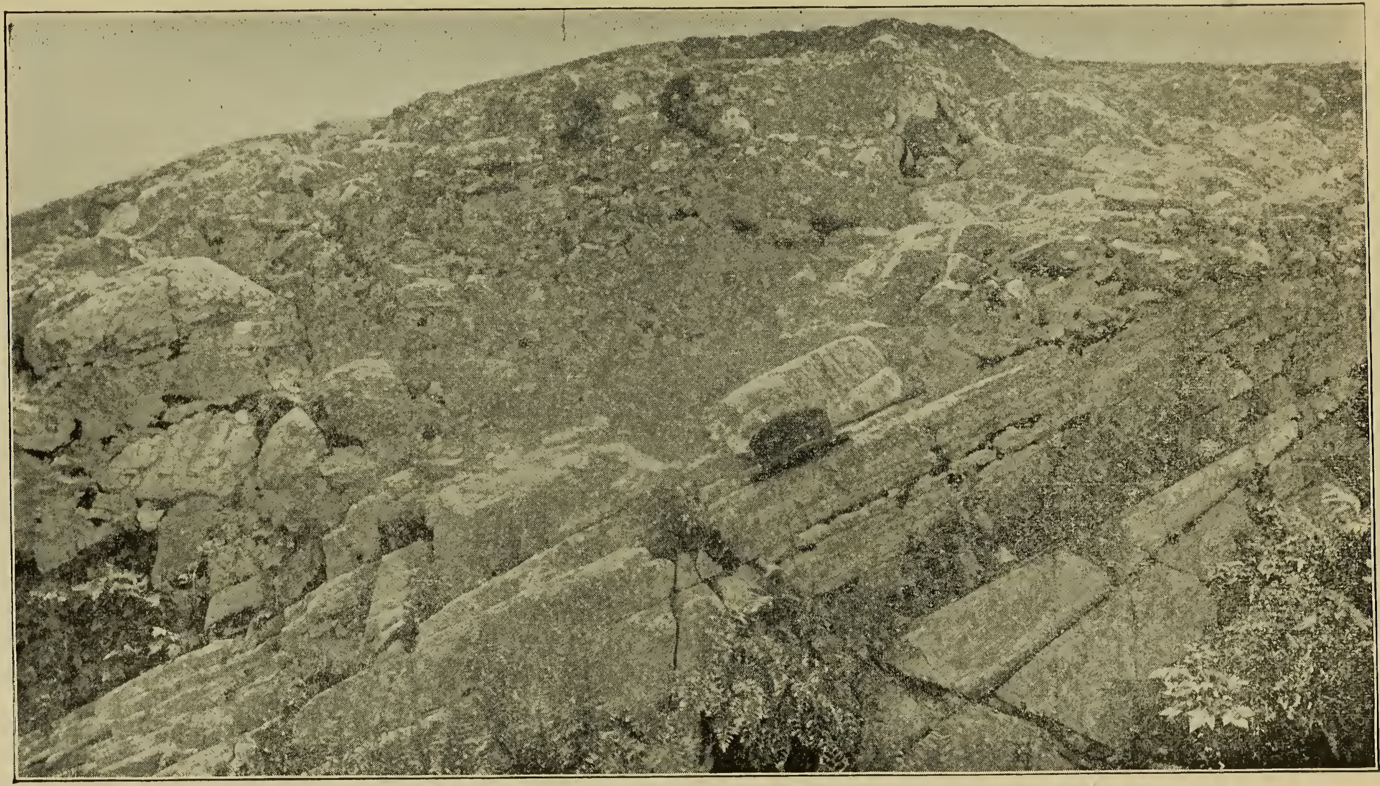
Potsdam sandstone.— This formation is prominent to the north and east but is not represented on the Mohawk. Vanuxem has expressed the opinion that it merges into the Calciferous to the southwestward and I believe this to be the case. The lateral merging of arenaceous into calcareous deposits is quite clearly exhibited in several districts, and the vertical gradation is nearly everywhere apparent.

The Potsdam formation, in the region to which the paper relates, is somewhat variable in character. In larger part it is a moderately hard, regularly-bedded, light-colored, fine-grained sandstone. In places it is quartzitic, particularly near its base, or where its thickness is slight. Locally its basal member is a coarse conglomerate of quartz and crystalline rock fragments, but generally its lower member is a dark quartzite. In its upper portion it becomes calcareous and merges through a soft calcareous sandstone into the arenaceous limestone of the Calciferous.

In Saratoga county it is conspicuous west of Saratoga Springs and through Greenfield township to Corinth, or Jessup's Landing; at East Galway, West and North Galway, and thence at intervals to and through Northampton township into eastern Mayfield. It outcrops again in considerable amount on the uplifted block west of Johnstown. In the western part of Fulton county the formation probably is present, but the drift cover is wide and heavy in this region and I was unable to discover outcrops. The last exposure that I find to the westward was on Spruce creek, just north of Diamond hill. To the eastward it is supposed that Potsdam underlies the Calciferous extending north from Saratoga Springs to Lake George, but it is thrust down against the fault along which the crystalline rocks rise so prominently between these two points.

Exposures at Jessup's Landing.—In the south bank of the Hudson in the vicinity of Corinth or Jessup's Landing there are the finest exposures of Potsdam in this region. They extend to the falls about half a mile below the landing, in bluffs averaging forty feet in height. In plate 1 a portion of this exposure is represented.

PLATE 2.



POTSDAM CONGLOMERATE LYING ON CRYSTALLINE ROCKS, NEAR MOSHERVILLE, N. Y. LOOKING SOUTH.

The beds about Jessup's Landing are in greater part white, light gray to buff, thin and regularly-bedded sandstones. They vary from moderately hard to semi-quartzitic. Their contact with the crystalline rocks is exposed at a number of points, and the basal beds are seen to be locally and irregularly conglomeratic. The floor of crystalline rocks is moderately smooth and mainly inclined to the west. Near the falls and mill at Palmer the crystalline floor rises up steeply to the east and north. In plate 5 the crystalline rocks are plainly shown in the middle ground, extending back to the base of the cliff. The Potsdam beds do not appear to cross the river unless possibly to the westward under drift. The beds are quarried at Jessup's Landing for local use, and in the quarries some fine examples of ripple marks were noticed.

South from Jessup's Landing exposures are rare, owing to heavy drift cover. On the hilltop half-way between South Corinth and Porter's Corners an outcrop is seen along the road of light-colored, semi-quartzitic slabby sandstone dipping gently westward. A thickness of about two feet is exposed over an area of fifty square yards.

West of Saratoga Springs the Potsdam is exposed over a considerable area. For this general region Mr. Walcott * estimates the thickness of the Potsdam at 200 feet, of which about forty feet of the upper members are exhibited three miles north of Saratoga Springs. The most extensive exposures are in the railroad cuts near South Greenfield, where forty feet of the formation are seen just west of the fault. The beds are mostly dark gray sandstones, in part quartzitic and from eighteen to twenty-four inches thick. There are calcareous layers of light buff color, and one dark bed is made of rounded grains of oolitic aspect. These beds are overlaid by oolitic limestones half a mile south. In the plain east of the fault there are exposures of lower beds near the crystalline rocks, which consist of white to gray quartzitic sandstones with quartz pebbles in places. These beds are separated from the Calciferous on the east by the central fault. In the southwestern corner of Greenfield township there

* Second contribution to Studies on the Cambrian Faunas of North America, U. S. Geological Survey, Bull. No. 81, p. 346.

are exposures of basal conglomerates which were described by Steele in 1823.* His description is as follows:

"*Pudding stone.*—This conglomerated mass of rocks is found in the town of Greenfield, not far from its south line on the southeast side of the Kayaderosseras mountains, resting upon the primitive rocks. It consists of rounded pebbles of quartz from the size of a small shot to that of a man's head, united into one common mass by a kind of coarse ferruginous sand. It extends along the mountains to no great distance, but fragments of it lie scattered in all directions, and, indeed, are found along the whole extent of the south line of the town of Greenfield, and in various other places. At present I am not acquainted with any other locality of the rock."

I have found another notable exposure of this sort of rock one and a half miles west of Mosherville just north of the turnpike. One of the best outcrops is shown in plates 2 and 3.

The lowest beds of this conglomerate consist of a breccia of angular to sub-angular fragments of the underlying crystalline rock, which is very quartzose and light colored; and quartz in a matrix of quartz sand. The surface of the crystalline rocks beneath this breccia is exceedingly irregular and the derivation of the fragments is illustrated in every stage.

The relations of these conglomerates to overlying members of the formation are exhibited in the slope southward by quite an extensive series of exposures. The coarse conglomerate gives place rather abruptly to a conglomerate or conglomeratic sandstone with quartz pebbles up to an inch in diameter, which grades upward into a calcareous sandstone containing very small pebbles and coarse sand grains. To the south lie very arenaceous limestones which may be in immediate succession, but it is probable that the Hoffman's Ferry fault passes between, cutting off the intermediate series of typical Potsdam sandstone beds which are exposed to the west and to the east of this locality.

The exposures to the east are a mile south of East Galway, where in the northern slope of a depression draining out to the southeastward there is a complete series of exposures from Calciferous sandstones to crystalline rocks. The Potsdam sandstones

* Geology of Saratoga county. Memoirs of Board of Agriculture of the State of New York, vol 2, p 53.

PLATE 3.

ERODED SURFACE OF POTSDAM CONGLOMERATE, NEAR MOSHERVILLE, N. Y.

are finely represented by 100 feet of gray to buff quartzitic slabby sandstones with a few inches of conglomeratic quartzite at its base. The contact with the crystalline rocks is plainly exposed along the road side and the relations are markedly different from those in the exposure near Mosherville in the absence of heavy conglomerate and a relative smooth surface of crystalline rocks. Here we probably have deposits laid down at some distance from the shore in relatively quiet waters. South of this small inclosed crystalline rock area the Potsdam beds appear to be cut off by the branch of the Hoffman's Ferry fault, as explained elsewhere.

The Hoffman's Ferry fault brings up Potsdam sandstones west of Galway, which are well exposed in the slope of the fault scarp on the road to West Galway. They are gray, slabby sandstones, more or less quartzitic, and a thickness of about eighty feet is seen from the bottom of the valley to the crest of the hill. Typical Calciferous outcrops are found a short distance west.

There are small exposures of dark quartzites of Potsdam horizon at several points in the next depression to the northwest, about the edges of the Amsterdam reservoir. Also at Union Mills with Calciferous just west and again in the depression one mile south-southeast of Union Mills, and in the creek at Fayville. The formation appears to cover a considerable area in the western part of Providence township and the southeastern corner of Edinburgh township, but the slopes to the crystalline hills are heavily drift covered and outcrops are very rare. This is also the case in Northampton township. There are several exposures east and south of Northville. They are of hard, slightly calcareous, gray-brown sandstones dipping gently southward and not exposed in any great thickness. At one point on the upper road a mile and a half southeast of Northville there are quartzitic beds seen nearly in contact with gneiss and in the slope half a mile south of here about twenty feet of hard-gray and brown sandstones are exposed near the roadside.

At a point two miles due west from Osborn's bridge there is a quarry in Potsdam sandstone exposing a considerable thickness of the formations. The beds are light buff in color, of moderate thickness, regularly bedded and in some layers ripple marked. On close examination the stone is seen to be speckled with dark-brown spots. In lower lands to the west there is a Calciferous area separated by the fault which extends from near Mayfield, but Cranberry creek cuts through to the Potsdam members. These are dark gray to buff quartzitic beds with a thin intercalated bed of dark shales. They are traversed by a gentle synclinal near the road bridge and appear to be cut off by the fault just east.

On the road from Cranberry creek to Mayfield the Potsdam beds are again brought up together with underlying crystalline rocks apparently by the cross fault. They are exposed to a thickness of forty feet up the slope along the small stream by the road and consist of sandstones and quartzites of the usual character. They are overlaid by Calciferous sandrock to the west and are cut off by the fault to the south and east. The relations of the formation in the Osborn's bridge — Mayfield region are shown in figure 1.

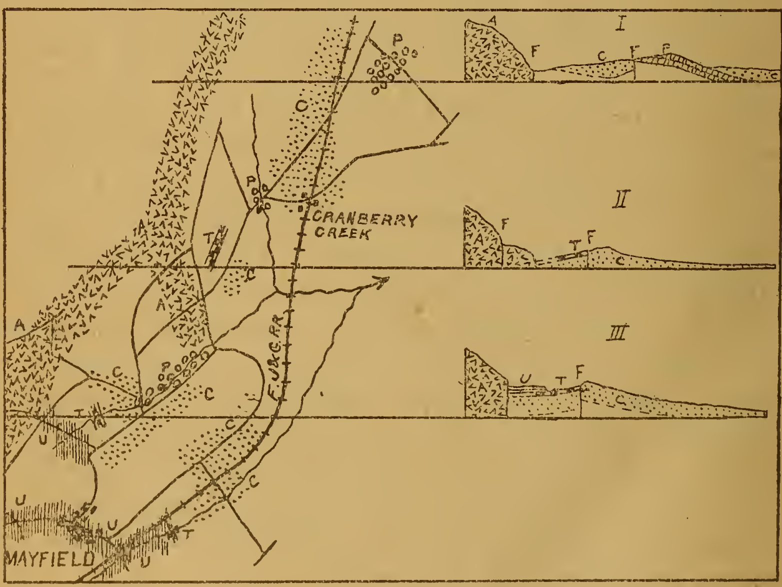


FIG. 1.— Sketch map of region north of Mayfield and sections illustrating the relations of the faults. Horizontal scale 2 miles to 1 inch. U., Utica slate; T., Trenton limestone; C., Calciferous sandstone; P., Potsdam sandstone; A., Crystalline rocks; F., Faults.

The Potsdam at Wells on the upper Sacandaga is exposed in considerable force just east of the lower part of the village. It consists of a somewhat calcareous sandstone weathering to a

PLATE 4.

FAULT AND DIKE IN EAST BRANCH OF EAST CANADA CREEK, NEAR MANHEIM, N. Y.

rusty color, alternating with lighter-colored quartzitic beds, of which one conspicuous member is a light-gray quartzite about four feet thick. The total thickness exposed is about twenty-five feet. The relations of this outlier are shown in figure 2.

Fig. 2. — Cross-section of Sacandaga Valley, at Wells, Hamilton county, N. Y. Looking north. U., Utica slate; T., Trenton limestone; C., Calciferous sandstone; P., Potsdam sandstone; A., Crystalline rocks; D., Drift.

The exposures of Potsdam sandstones west of Johnstown are on the high ridge west of the "Noses" fault scarp and cover an extensive area. The formation consists of light colored, rather massive sandstones. They are moderately soft, but usually quartzitic near the contact with the crystalline rocks. The contact with the crystalline rocks was not observed, but it was seen that there is no conglomerate exposed in their vicinity. The best exposure in this region is in a quarry along the road, half a mile north of Keck's Centre, where twenty feet of cream-colored sandstones are exhibited in beds two to three feet thick. Near their base there is a thin intercalation of drab-gray shales which outcrops on the road a couple of rods north of the quarry.

These beds become calcareous southward and may also thin. Approaching the Mohawk they have either thinned out or merged into the Calciferous, for this formation is seen at several points within a foot or two of the crystalline rocks along the slope of the fault scarp. At the "Little Nose" the contact is finely exhibited on the south side of the river in a cut of the West Shore railroad. This contact was described and figured in the fifth annual report of the State Geologist, page 10, published in 1886.*

In plate 8 the general features of the outcrop are shown.

In the report just cited Prof. Hall gives the sequence from below upward as labradorite, ferruginous labradorite, decom-

* Field Notes on the Geology of the Mohawk Valley. 5th Report of State Geologist (of New York) for 1885, pp. 9–10.

posed gneiss, ferruginous and chloritic material, small lenticular masses of clay and chloritic matter, breccia containing Potsdam sandstone fragments, crystalline limestone, quartzite, etc., and Calciferous sandrock. The interval from gneiss to Calciferous "represents the Huronian, Primordial and Potsdam." "These formations represented elsewhere by many thousand feet of sediments are here represented by from a few inches to several feet of breccia and loose chloritic and ferruginous material." It is stated that part of the ferruginous and chloritic material "is derived from the decomposition of the gneiss with some slight sedimentation."

At the time of my examination the materials immediately below the breccia were so deeply weathered that I could form no definite opinion as to their relations. They did not, however, appear to be the products of sedimentation. They seem to merge into the deeply weathered crystallines below, of which the structure is still evident. The breccia is sharply separated at its base, as I believe plate 8 clearly shows. Its matrix is Calciferous sandrock and it merges into the overlying members, the fragmental constituents guadually decreasing in number and size. These fragmental materials consist, so far as I could find, solely of Calciferous sandrock, in part similar to the matrix and in part of a somewhat darker variety which is often observed near the base of the formation in the region northward. The fragments are angular or subangular and in a few cases rounded. They vary in size up to about four inches.

At Little Falls the Calciferous sand rock is seen to lie directly on the crystalline rocks.* There are many exposures,† and in all cases that I observed the lower members were typically Calciferous

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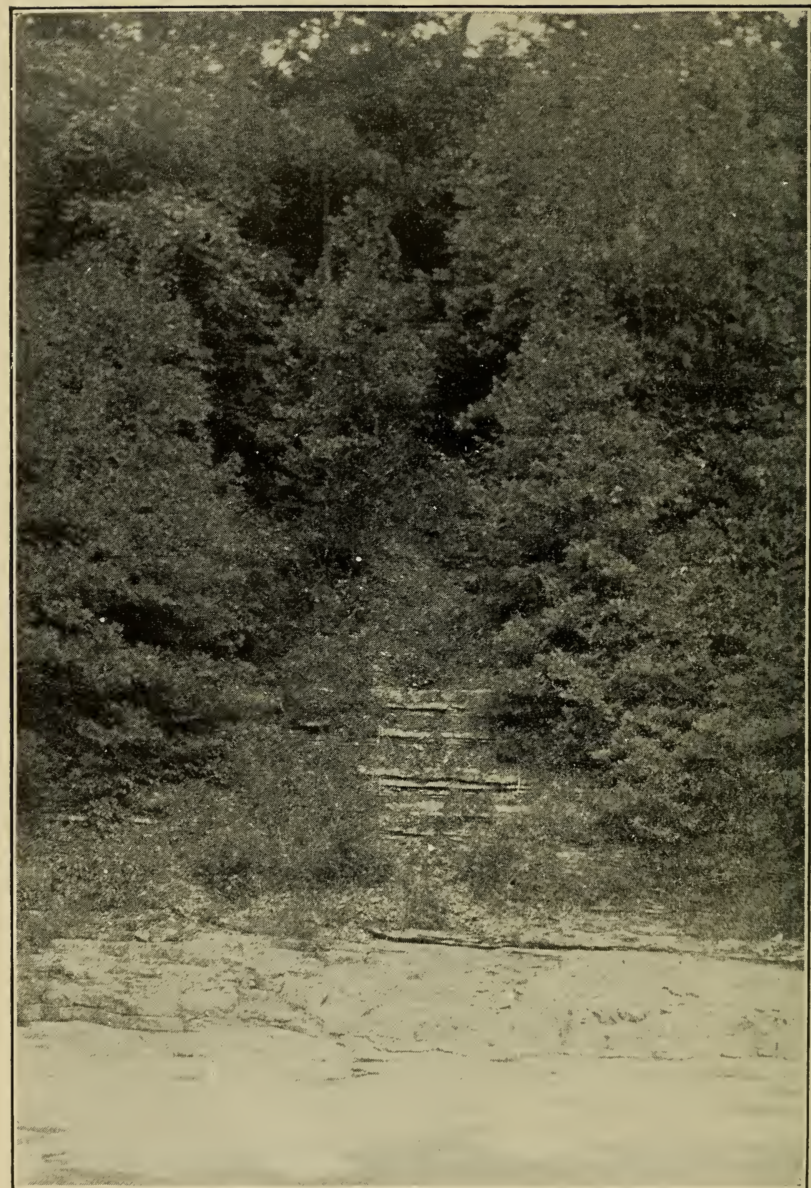
* Walcott, Correlation papers, Cambrian, U. S. Geol. Survey, Bull No. 81, p. 347.

† Note — This statement of many exposures of the Calciferous sand rock lying directly upon the crystalline rocks is an interesting one, since, in the two or three previously known exposures along the Mohawk valley, the Calciferous has been shown to be separated from the crystalline rocks by an intervening deposit At Little Falls, on the south side of the river, there was formerly a good exposure, but which in recent years has been covered. This exposure, however, showed the base of the Calciferous resting upon a ferrugineous deposit of clay and sand, having a thickness of about eighteen inches, which intervened between the Calciferous and the crystalline rocks. Many years since there was a locality upon the north side of the Mohawk at the "Noses" where the succession of the Calciferous and crystalline rocks was exposed, but at this locality there was a considerable amount of material intervening between the two which could not be identified with either of the formations. The exposure upon the south side of the Mohawk has already been referred to, and the section in the report of the State geologist for the year 1885 shows the order of succession at that place.—H.

PLATE 5.



North Bank of Creek Behind Canajoharie, N. Y. Exhibiting the Relations of the Trenton Limestone.

PLATE 6.

Trenton Limestone in a Quarry at Howland's Mill, Saratoga County, N. Y.

although an increased amount of arenaceous material is usually apparent for the first few inches above the crystalline rocks. Walcott refers to the discovery by Professors Shaler and Williams of a thin layer of shale containing a Potsdam fossil, *Lingulepis acuminata*, at this locality. The layer is said to lie on a basal bed of sandstone, on the north side of the Mohawk. Walcott, in commenting on the value of this evidence, states, "as this species ranges up into the Calciferous at Whitehall, New York, and on the north side of the Adirondacks it is doubtful if we can claim the presence of the Potsdam at any point in the Mohawk valley."

Along the southern edge of the crystalline area north of Little Falls there is heavy drift cover and I found but one exposure of the Potsdam horizon. It is a locality referred to by Vanuxem.* at the paper mill on Spruce creek a short distance north of Diamond hill. Here there is a "coarse gray rock, resembling in parts, at first sight, a decomposed granite; that is, a granite whose mineral constituents had been separated and reunited again, without much, if any, change of place. The first layer is about six inches thick and contains fragments of vitreous quartz, which are likewise found in some of the layers" of Calciferous "a few feet above."

From this locality for many miles northwestward the base of the Calciferous was not observed, and in the eastern part of Oneida county the Black River limestone lies upon or against the crystallines, so that the Potsdam horizon is not near the surface.

Calciferous sandrock.— This formation covers a wide area in the region to which this paper relates. It is brought up along the Mohawk by each of the principal faults and extends northward more or less widely to the crystalline rocks. Except where covered by drift it outcrops conspicuously in cliffs along the river and creeks and has more or less bare surfaces over the intermediate regions. Its typical character is uniform throughout; a light bluish-gray, fine-grained, massively-bedded arenaceous limestone, with a characteristic glimmering surface on fresh fracture. On exposure it becomes lighter, usually of a dirty buff tint. There are certain beds presenting more or less persistent

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* Loc. cit., page 28.

individual characteristics, but these are not conspicuous features; the fucoidal layers of Vanuxem and the oölitic layers of Saratoga county are the most noteworthy, exceptional members.

Fine exposures of the Calciferous are very frequent. The most notable are as follows: About Middleville, Little Falls and northwestward along the fault scarp, on East Canada creek (as shown in plate 9); about St. Johnsville; along the Mohawk from Canajoharie to the "Noses;" the quarries at Tribes Hill; along the Mohawk from Amsterdam to Hoffman's Ferry; along the fault scarp in the southwestern corner of Saratoga county and west of Saratoga Springs. The formation has a thickness of 200 to 250 feet on the Mohawk, and the amount appears to be constant over a wide area. The fucoidal layers are near the summit of the formation and are quarried at many points along the Mohawk. The oölitic layers are best developed in Saratoga county, where they were first described by Steele.*

A conspicuous and interesting feature of the Calciferous is the frequent occurrence of cavities containing finely-developed quartz crystals, together with more or less calcite. Anthracite occurs quite frequently in these cavities and in the quartz crystals, as well as occasionally in thin plates on bedding planes, particularly in the Middleville, Little Falls and Canajoharie regions.

According to Walcott† the members of the Calciferous near Saratoga are as follows:

	Feet.
Massive layers of steel gray, more or less arenaceous limestone	125
Massive-bedded, slightly magnesian, gray and dove-colored limestone with numerous small, narrow-chambered cephalopoda near the summit	35
Unfossiliferous, impure, compact, more or less silicious limestone	95
Dark-gray, evenly-bedded limestone (with a Dicellocephalus fauna)	50
Oölitic limestone	30

* Am. Jour. Science, vol. 9, pp. 16–18.

† Correlation papers, Cambrian, U. S. Geol. Survey, Bull. No. 81, p. 346.

PLATE 7.

Falls Over Utica Slate in the Ravine Behind Canajoharie, N. Y.

PLATE 8.

Contact at the Base of the Palaeozoic Rocks. West Shore Railroad Cut, One Mile West of Downing Station (Formerly Randall). Looking South.

The last lying on the Potsdam sandstone. The two basal members are considered the closing deposits of the Cambrian, and the opinion is expressed that if a fauna could be found in the next bed above, it would probably serve to connect the Cambrian and lower Silurian (Ordovician) faunas.

The oölitic member of the Saratoga region is thus described by Steele: *

"The calcareous concretions which characterize and identify this formation are for the most part arranged in successive layers throughout the strata in which they appear; they are globular, of the size of a mustard seed, possess a shining black color and are evidently composed of concentric layers. They are united in the mass by a calcareous cement, more or less granular, combined with fine silicious sand. More than one-half of the whole mass of some of the strata, which constitute the series of this formation, consists of these globular concretions; in others they are more sparingly diffused." There is associated with this stratum a two-foot bed of the *Cryptozoon proliferum* of Hall, which resemble large concretions made up of tubular concentric layers of dark color. The principal mass of oölitic limestones lie below the Cryptozoon bed, but there are oölitic streaks in portions of the immediately overlying beds. According to Mather† the Cryptozoon layers are exposed at several points about Galway village, and according to Vanuxem the oölitic structure is also exhibited at the "Noses;" also a few miles above the paper mill on Spruce creek and near Northampton.

North from Saratoga Springs to Lake George there are no extensive exposures of the Calciferous sandrock, owing largely to the heavy drift cover. Small outcrops are not infrequent, but they are of the usual type so far as I could find. At Glens Falls a gentle anticlinal brings up the formation so that it is bared by the Hudson river over a small area, rising but a few feet above water level in the northern bank. Its relations are shown in the accompanying plate.

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* Loc. cit. p. 17. † Loc. cit. p. 416.

The outlying area at Wells is an interesting occurrence of the formation. It is of the typical, light-colored arenaceous limestone.

In the western portion of Saratoga county the lower member of the Calciferous formation is very arenaceous and weathers to a darker color than usual. In this region there is an included bed of pure white flinty quartzite which is also occasionally observed in the region westward. West and south of Galway it has a thickness of from three to eight feet and is a prominent feature at many points. It is also exposed on the hilltop half a mile south of Mosherville. Its stratigraphic position is about eighty feet above the base of the formation. A bed of similar quartzite or flint, of dirty buff color, was also observed on the upper road from Little Falls to Manheim Centre, about half a mile east of the Little Falls fault, and on the valley turnpike, two and a half miles east of St. Johnsville. These last-mentioned occurrences appear, however, to be in a somewhat higher horizon than those of the Galway region.

East of Galway, near the first cross road, three feet of buff calcareous shaly beds are seen interbedded in the upper portion of the Calciferous, and similar beds at about the same horizon outcrop just north of the upper road from Amsterdam to Johnstown at a point one and a half miles due north of Tribes Hill station.

The fucoidal layers of Vanuxem are a characteristic member of the Calciferous over a wide area. They are well exposed in many of the quarries along the Mohawk, where they are worked extensively for building stone. Their character and distribution have been described with care by Vanuxem, and I have but little to add to his statements for the Mohawk valley. The member consists of a fine-grained, thick-bedded limestone intermediate in character between the typical Calciferous and Birdseye deposits with intercalcated streakings, blotchings, reticulations and sprinklings of mixtures of coarse sand and Calciferous materials of light color in greater part, but weathering dark. The alternations are in thin layers at varying but frequent intervals, and the bedding of the fine-grained material is usually more or less disjointed into a partial breccia. The coarse materials are disposed in forms suggesting fucoids, and this resemblance has given the name to the member. Fossils are usually present and

PLATE 9.

Calciferous Sandrock on East Canada Creek, Between the Straw-board Factory and the Fault. Looking North.

constitute a limited but characteristic fauna. This member appears to have a thickness of about fifteen feet in the Mohawk valley. There is an excellent exposure in the lower quarries at Tribes Hill along the railroad, about 300 yards east of the station. Here the basal member is a three-foot bed of dense, dark-gray limestone, with only a moderate amount of interbedded streakings of the dark, coarse sand, and its aspect is mainly typical Calciferous. Above this there are three and a half feet of lighter colored similar limestones, with only occasional interstreakings of "fucoidal" character. Then there are ten feet of very massive, dark limestones of alternating dense birdseye like limestone and coarse, sandy "fucoidal"-like beds. This series weathers very light. Above are eight feet of massive beds with some "fucoidal" features, but in greater part of Calciferous type. These merge upward into ten feet of Calciferous sandrock, very arenaceous but quite soft, in beds of eighteen to twenty-four inches, which constitute the surface of the top of the exposure.

At Canajoharie the quarrying operations have been extensive in the "fucoidal" beds. Vanuxem* has described the members at this locality in considerable detail. They have a thickness of about ten feet and lie about six feet below the top of the formation.

The "fucoidal" member is to be seen at many points about Amsterdam in the quarries along the river and behind the town and in various stream cuts, including those on the opposite side of the river.

At Little Falls the thickness is greatly diminished, and Vanuxem states that he has observed fucoidal members at various points in Fulton county, where the distinctive characters are presented, but the thickness is slight. I observed an excellent exposure of this member and its associates in Washington county in a stream bed at a point five miles due east of Glens Falls, where it has a thickness of one foot. The bed lies on typical Calciferous sandstone and is overlaid by a two foot bed of dark blue, very compact limestone, probably of Chazy age.

As to the existence of the Chazy formation in the Mohawk valley I have no new evidence to present. Walcott† states that at Little Falls and Fort Plain it is absent.

* Loc. cit. p. 37. † Loc. cit. p. 23.

Birdseye, Black River and Trenton limestones.— This series of limestones constituting the Trenton group presents considerable variation in character from east to west and north to south and the Black river beds are apparently wanting in the Mohawk valley. Vanuxem's statements regarding the character of these formations are particularly explicit, and I shall present only a summary of the general facts with some additional statements regarding certain local features and distribution.

The Birdseye member is in greater part an impalpably fine-grained, light dove-colored limestone more or less filled with dark-colored, vertical, columnar fucoidal stems. It weathers to white or a light ash gray tint, which is an especially characteristic feature. Owing to its very fine grain and compact structure its fracture is smooth or conchoidal and the texture of the rock is rather brittle. The ends of the dark fucoidal stems which are spotted over the surface of the bedding planes resemble birds' eyes, and from this feature the name of the formation is derived. It is in moderately heavy, regular beds and has a vertical cleavage. In some localities its color is dark gray or black, but the light weathering is general. Exposures are very abundant in the Mohawk valley, mainly in the many quarries at which the beds have been worked. The beds lie directly on the surface of the Calciferous sandstone usually with a sharp break, which suggests an intervening unconformity by erosion. In the Mohawk valley the formation attains its maximum thickness of nine feet about Fort Plain. The amount decreases westward to seven feet in the many exposures east of St. Johnsville; it is five feet on East Canada creek, five feet at the fault in the hollow three miles northwest of Little Falls, four feet about Little Falls and to the southeastward and five to six feet on West Canada creek about Middleville, Newport and Cold Creek. At Ingram's Mills on East Canada creek there are some unusual features in this formation and its relations. The section is as follows:

	Feet.
Thin-bedded, black, very fine-grained limestone, with slaty intercalation; it extends to top of bank; Trenton........	8
Loose, pyritiferous, impure limestones of dark color, with diminutive birdseye fucoids	1
Light-colored limestone, with a moderate amount of "birds-eyes"...	1½

PLATE 10.

The Principal Cataract at Trenton Falls, N. Y. Exhibiting the Upper and Medial Members of the Trenton Limestone.

PLATE 11.

Lower Gorge at Trenton Falls, in the Lower Members of the Trenton Limestone.

	Feet.
Typical birdseye layers	2½
Moderately-dark, compact limestone, no "birdseyes"	2⅛
Very hard, dark, compact limestone, with 14 inches black bed at base, no "birdseyes"	3
Light-colored limestone, compact in part, with a few widely-scattered "birdseyes" in more compact portions	3
Light-colored, moderately compact, even-grained limestone in six to ten-inch layers, intermediate in character between Birdseye and Calciferous	6
Thin-bedded, soft "Calciferous"	1⅙

In the small inlying exposure at Ephratah at a quarry a mile east of Salisbury Centre and in the exposures near the fault southwest of Keck's Corners the full thickness of the Birdseye beds is not exhibited, but the typical characteristics are presented. At Canajoharie the Birdseye formation is not characterized and the Trenton appears to lie directly on the Calciferous. At Tribes Hill and about Amsterdam the formation is represented by from three to five feet of very compact, gray to black, thin-bedded limestone, with very rare birdseyes. They are sharply separated from a somewhat irregular surface of the Calciferous sandstone, a relation which is clearly exposed in the creek behind Amsterdam in a small gorge at an altitude 115 feet above the railroad depot. The south dip is steep here.

The easternmost locality of the formation that I have observed is at Rock City Falls. Here there is a three-foot bed of dense, dark limestone which has the characteristic, white weathering, etc., of Birdseye limestone and contains a few ill-defined fragments of fucoids.

In the eastern and southern part of the region the Birdseye horizon appears to be represented by a series of very fine-grained black limestones, which weather white or light gray and contain a fauna of small cephalopods and gastropods. This has been considered the basal member of the Trenton, but its lithologic characters and position are strong evidences that it is of the Birdseye horizon. It is seen about Amsterdam, particularly in a creek bed on the opposite side of the Mohawk, where it has thin intercalations of black, coarse-grained limestones containing Trenton brachiopoda. It is well exposed to a thickness of six feet in an old quarry, three and three-quarter miles due north of Amsterdam station; in a quarry and at the bridge a short way above Steever's mills, in Broadalbin, about Galway, near the Hoffman's Ferry fault two miles north of the Mohawk and with much interbedded thin layers of Trenton, at Glens Falls some distance below the black marble beds.

In the central Mohawk valley region the Birdseye member is succeeded abruptly by the Trenton limestones, suggesting, as stated by Vanuxem, a break in the stratigraphic succession in that region. This was found to be very apparent in the Little Falls and West Canada creek regions, but farther northward the gap is occupied by the Black River limestone beds. In a small area near Amsterdam and in the Glens Falls region the Black River beds appear to be represented, together with a heavily-bedded member at the base of the Trenton. In a small stream emptying into the Mohawk opposite Amsterdam there is a three-foot bed of coarse limestone of dark gray color containing corals, including *Columnaria alveolata*, which I believe represents the Black River horizon. It lies on the representative of the Birdseye horizon, a six-foot bed of very fine-grained, black limestone, which weathers very light colored and lies in turn on Calciferous beds containing *Ophileta.*

At Glens Falls there is a three-foot bed of hard, compact, dark limestone, with black shale streaks, which holds abundant *Columnaria* and other corals of the Black River fauna. It lies directly on the "fucoidal" member of the Calciferous series. Five miles northeast of Glens Falls at a point three and one-quarter miles due northwest of Dunham's Basin a small stream exposes a two-foot bed of very compact dark limestone lying on the "fucoidal" bed, which may possibly be Black River. At Rock City mills the formation is absent unless I am mistaken as to the identity of the supposed Birdseye beds mentioned above. Walcott* gives the thickness of the Birdseye limestone as six feet and the Black River limestone as four feet at Saratoga.

The Trenton limestone comprises three principal members, of which only two have been observed occurring together. From eastern Oneida county southward the upper member is a thick-

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* Loc. cit. p. 346.

PLATE 12.

Cliffs on West Canada Creek in Trenton Falls Gorge, just Above the Railroad Bridge. Upper Beds of Trenton Limestone.

bedded, coarse-grained, light-colored crinoidal limestone. This is underlaid by a series of thin-bedded, dark limestones, with more or less intercalated black shale, which is of general occurrence and constitutes an upper member eastward, or the entire formation. Then there is a very massive, dark, coarse limestone which begins as a basal series near the Mohawk in the eastern part of Montgomery county and extends to the southeastward, coming out in great force at Glens Falls, where it is extensively quarried for black marble. The upper massive series appears to be a development of the upper portion of the thin-bedded Trenton, a feature which is exhibited in the fine series of exposures extending along the south slope of the West Canada creek valley from Newport to Trenton Falls. The lower massive series appears to be an older member of the formation overlapped westward and apparently to some extent near its southern termination by the thin-bedded series. The greatest development of the Trenton which I have observed is at Trenton Falls, where there appears to be a thickness of 120 feet, although I made no careful measurement. Owing to the dip of the beds down stream and the variability of the rate of dip the total amount of fall is not a measure of the thickness.

In the accompanying plates some idea is given of the aspect of the several members of the formation at Trenton Falls and of a portion of the falls and gorge to which they give rise.

Descending the West Canada creek valley the Trenton limestones gradually decrease in thickness, and south of Middleville I found only thirty feet, consisting entirely of thin-bedded members. Descending the Mohawk the thinning gradually continues to Canajoharie, where the amount is only six feet. The formation is well exposed on the creek behind Canajoharie. It consists of thin-bedded, dark-colored, semi-crystalline limestones, with black shaly intercalations lying on a very uneven concretionary surface of the Calciferous sandrock to which its beds are flexed to conform. They are, however, sharply separated at the contact by an apparent unconformity. In plate 5 some of these features are shown together with the overlying Utica beds.

The thickness gradually increases eastward and northward from this locality. At Tribes Hill station the lower massive member makes its appearance and is extensively quarried. There are at this locality twelve feet of moderately coarse-grained, dark-colored limestones in beds one to two feet thick, overlaid by twenty-three feet of dark-colored, thin-bedded members containing lighter-colored streaks of limestone below and thin intercalations of black slates above. The massive series lies on four feet of very compact gray beds, with abundant gasteropoda and cephalopoda, which in turn lie on the thin series of typical Calciferous members overlying the "fucoidal" beds. These features continue in the region about Amsterdam and eastward to the Hoffman's Ferry fault, the massive series becoming somewhat thicker and coarser grained in the easternmost exposures. In the quarries and stream cuts north of Amsterdam there are exposed seventeen feet of the coarse-grained, massive series here, rather thinner-bedded than usual. At the extensive quarries, two miles northwest of Hoffman's Ferry, the lower member is very coarse-grained, soft, massively-bedded, highly fossiliferous limestone and has a thickness of about twenty feet. It is separated from the Calciferous sandstone by three feet of dark-colored, very compact limestone. In the bed of a creek in the slope south of the Mohawk opposite Amsterdam there is a fine, continuous exposure from the Utica slate to the Calciferous, in which the coarse, massive beds are lacking. The members are as follows:

Utica Slate:

	Feet.
Thin-bedded, dark, very fossiliferous limestone, with black shale intercalations toward the top; Trenton	12
Darker, coarser-grained, more massive limestone, in beds from two to four inches thick, very fossiliferous; Trenton,	8
Compact, dark, heavily-bedded limestones, weathering much lighter and containing cephalopoda and gasteropoda, with several thin intercalations of dark, coarse-grained limestone containing many Trenton brachiopoda; Birdseye...	8
Dark-gray, moderately fine-grained limestone containing Black River corals, including *Columnaria*	3
Very compact, fine-grained, dark-colored, massively-bedded limestone, weathering somewhat lighter................	6

Mottled lighter and darker gray, arenaceous limestone, with glimmering fracture, contains *Ophileta* near the top.

PLATE 13.

NORTH BANK OF THE HUDSON RIVER AT GLENS FALLS.

This last member, which is typical Calciferous, is separated from the overlying beds by a sharp break.

North from Amsterdam the formation extends west of Perth to the hills south and east of Fonda's Bush, probably uniting with the area extending along the Tribes Hill fault. Owing to heavy drift cover its distribution in this region could not be definitely determined. The only outcrop found in this belt was in an old quarry three and three-quarters miles due north of Amsterdam station, where the Birdseye beds are exposed.

North of Mayfield there are two small areas of Trenton limestone lying between the faults which are well exposed in a quarry is the with the relations shown in figure 1. The southernmost in each, thinner-bedded upper members of the formation, and the northern area exhibits the coarse-grained, massive beds of the lower member.

At the saw-mill a mile due southwest of North Broadalbin there is a fine exposure of upper Trenton beds in the creek. There are exhibited fifteen feet of thin-bedded, dark-colored, very fossiliferous limestones. Similar beds are also seen at a somewhat lower horizon just above Steever's mill, with underlying brecciated beds of fine-grained, light-colored limestones.

Near Galway there are several exposures of lower members on the blocks between the faults. They are only moderately-massive and are underlaid by thin-bedded, very fine-grained beds containing cephalopoda and gasteropoda and weathering light-colored. At Rock City Mills the Trenton beds outcrop in considerable force, but not quite to their entire thickness. The amount exposed is twenty-eight feet, consisting of thin-bedded members below, with heavier-bedded and slightly coarser-grained beds above. Below is the three-foot bed of Birdseye limestone before mentioned, resting on Calciferous sandstone, from which it is sharply separated.

In the Trenton belt west of Saratoga there are several excellent exposures, of which the most noteworthy is the large quarry at Howland's Mill, three miles due west-southwest from the Springs. The nature of the beds in this quarry are in some measure represented in plate 6.

There are twenty feet of beds exposed in and about this quarry, but not the entire thickness of the formation, which is stated by Walcott to amount to more than forty feet in this region.

Between Saratoga and Glens Falls the Trenton is at first cut off by the Calciferous, brought up by the Springs fault, and then deeply buried beneath sands and glacial drift.

At Glens Falls there are superb exposures in quarries and cliffs along the both banks of the Hudson for half a mile or more. There is here a low anticlinal through which the river has cut down to the upper beds of the Calciferous, exposing in the banks all the members of the Trenton group of limestones. Plate 12 represents the exposure in the north bank with the bared surface of the Calciferous sloping out into the river for some distance on the right.

The section at Glens Falls (north bank) is as follows:

	Feet.
Thin-bedded black limestones in beds three to eight inches..	10
Black marble ten to fourteen-inch beds	3
Black marble in one or two beds........................	13
Black, massively-bedded, fine-grained limestone of floor of quarries, fucoids and crinoids on surface, with irregular dark-gray, very fine-grained streaks in middle...........	3
Dark-gray, mostly very fine-grained limestone in beds four to ten inches thick, with streaks of coarser, darker limestone containing Trenton brachiopods fracture semi-conchoidal; weathered surface light gray	25
Black, compact limestones in beds two to six inches thick, with black slate intercalations and abundant Black River corals, including *Columnaria.*	
	Inches.
Moderately dark-gray arenaceous limestone, with coarser-grained, darker reticulated blotchings in layers..........	7
"Fucoidal" layer of Calciferous	3
Black, shaly limestone	3
Calciferous sandstone..................................	at base

The upper members are cross-bedded at the falls, an unusual and curious feature for a limestone.

The aspect of the black marble beds and a portion of the overlying series of this locality is shown in plate 13.

In the Lake George region an interesting outlier of Trenton limestone was discovered five miles south of Kattskill bay abutting

PLATE 14.

Black Marble and Overlying Thin-bedded Limestone in a Quarry on the North Side of the Hudson River at Glens Falls, N. Y.

against the fault which extends from Patten's mills to and along the east side of Lake George. It is a thin-bedded, very fossiliferous limestone, with calcareous shale intercalations. The small Trenton area discovered at Wells* is on the west side of the Sacandaga and is extensively exposed north of the road to Sageville. It is a light-gray, moderately coarse-grained, highly fossiliferous limestone.

Utica slate.— I have made no special study of the Utica slate excepting at the immediate vicinity of the adjoining formations and the faults. Its characters are quite unmistakable throughout the Mohawk valley. They are very dark, evenly-bedded slates and shales, with alternating slabby beds at most localities. In the upper Mohawk region the lower slabby beds are especially hard and frequent.

One of the finest exposures in the Mohawk valley is in the deep ravine behind Canajoharie, a portion of which is shown in plate 5.

The outlying area of Utica slate at Wells is in the valley just west of the Sacandaga. It is a black shale of the typical variety, containing a fairly abundant Utica fauna.

Respectfully yours.

N. H. DARTON.

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* This outlier of Trenton limestone at Wells was described by Vanuxem and shown on the geological map of the State published in 1842. In a later edition of the map, 1844, accompanying the agricultural report, the Trenton limestone and associated rocks at Wells were shown as continuous from the Mohawk valley. In consequence of this representation the outlier referred to has been considered as a recent discovery.—H.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF ESSEX COUNTY.

JAMES HALL, STATE GEOLOGIST. | J. F. KEMP, ASSISTANT.

1893.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF ESSEX COUNTY.

By J. F. Kemp.

James Hall, *State Geologist:*

Sir.—The field work upon which the accompanying report is based was done in June and September, 1893. In the former month the writer was assisted by Messrs. W. D. Matthew, W. A. Pomeroy, T. G. White and E. Riederer. The expense was met by the Geological Department of Columbia College and by those engaged in the work. The townships of Ticonderoga, Crown Point, Essex and Willsborough were mapped. In September the expense was met by the State and the work was done by the writer and Messrs. H. Ries and Clarence Fenner. The townships of Elizabethtown, Lewis, Chesterfield, Keene, North Elba and St. Armand were traversed, the last two somewhat less thoroughly than the others. A disastrous flood during the closing week in August washed out nearly every bridge in the whole region, made the remoter highways impassable and was a great drawback, so that some outlying corners remain to be reached from neighboring and as yet untraversed towns. In connection with the writer's work Prof. H. P. Cushing, of Adelbert College, Cleveland, volunteered his services for further mapping, and his results in Clinton county are submitted in a following paper. His expenses were in part borne by our appropriation, but chiefly by himself, and the writer acknowledges gladly the valuable aid thus rendered.

The general plan of the work has been to traverse every highway affording information and so far as possible to record the rocks and gather specimens from the accessible mountains as well. The numbers on the maps indicate the places where outcrops are met and the location of the specimens which were collected and brought back for study. They show at a glance the proportionate part of the territory that has been actually seen in the field. Aside from the difficulties inherent in the geological problem itself, it is to be borne in mind that the country back from Lake Champlain is mountainous and in most places covered with a dense second growth of woods which mask the outcrops even when such occur. One may tramp for miles in the thick undergrowth without meeting a ledge. In addition to this the region is covered in many districts with glacial deposits which hide the rocks.

So far as possible we have endeavored to follow up the parties of the United States Geological Survey, who are making a topographical map of the region, and while in several towns we have been forced to rely on the county atlas for maps, in others we have based the outlines on the advance sheets, which have been most kindly furnished by Mr. H. M. Wilson, to whom, and to Mr. E. C. Barnard, of the United States Survey, acknowledgments are here made. Topographical maps are an indispensable aid in indicating the character of the country and many of its important geological features.

The problems involved in unraveling the stratigraphical relations are obscure ones, and about them one could not well speak finally until a greater extent of territory has been covered. But in the Archæan rocks the several different ones distinguished on the maps stand out in quite strong contrast and in typical instances are readily recognized. There are, however, intermediate forms that are very puzzling. Thus, the massive labradorite rocks of the Norian series of Hunt, are very evident when they furnish either the rich feldspathic varieties (anorthosites) or the dark gabbros; but both these shade into gneisses, with hornblende, pyroxene and quartz, so that when one meets a rather basic gneiss, far away from any massive rock, and containing these minerals, a reasonable doubt may arise as to whether it is a member of the older gneiss series or a later Norian intrusion. These difficulties are later brought out with examples. The study of the rocks has been carried out with microscopic determinations in the laboratory, and some hundreds of thin sections have been prepared.

It should be further stated that in the summer of 1892 the writer mapped Moriah and Westport townships under other auspices, and has already submitted a map and report upon them, which are uniform in scale and character with the accompanying. A sketch of the petrography of the "Gabbros along the west shore of Lake Champlain" was presented to the Geological Society of America in December, 1893.

The following pages give a preliminary general sketch, after which the individual towns are taken up with the accompanying maps.

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General Geological Relations.

Prof. E. Emmons in his Report on the Second Geological District of New York, 1842, gave a brief topographical and physical outline of Essex county, (pp. 194–216) and Chas. E. Hall, in his paper on the Laurentian Magnetite Iron Ore Deposits in northern New

York, brings out the general relations still more clearly. As they are closely connected with the geological phenomena, they are again briefly commented on here. The valley of Lake Champlain runs nearly due north and south, and is closely parallel to the trend of the Green mountains, although some distance west of them. It is a deep trough of erosion, doubtless more or less affected, or directed by faulting. It lies near the contact of the palæozoic sedimentary rocks and the archæan crystallines, but while sometimes having the latter for its western shores, it is in much the greater portion contained in the former, the latest of which is the Utica slate. The dips of all the palæozoic strata on the New York side are low and are inclined to the north or northwest, as will be seen by following up the shore of our maps. They thus give no evidence that a geosyncline outlined the lake basin, but rather contradict it.

The high lands of Essex county are all archæan and include Mt. Marcy and Mt. McIntyre, much the highest mountains of the State. These elevations in general are formed of northeast and southwest ridges, which, when they reach Lake Champlain, jut into it at a slight angle with its course. The lake sets back as a series of bays around the north ends of these. The palæozoic rocks extend back into the larger embayments, and in instances run goodly distances up into the hills, as at Ticonderoga and Crown Point, but they also form small remnants next the water-front. While a northeast trend is the general rule in the mountains, there are ridges which run nearly east and west, as is the case with Bullwagga mountain in southern Moriah, and Buck mountain in northern Ticonderoga, but back from the lake the general direction of the valleys is northeast, and all the larger streams, such as the Saranac, west and east branches of the Ausable, the Boquet and the Black rivers, flow in this direction until they can reach Lake Champlain around the north ends of the ridges. The southwesterly drainage in the limits of Essex county follows the same rule, and the Schroon, the Boreas and the North or Hudson river flow to the northwest, until in Warren county they come around in the Hudson proper to a southerly direction.

There is much reason to regard these valleys as chiefly due to faults and the mountain ridges as of the block-tilted type, but in massive and metamorphic rocks this can not be as readily shown as in continuous and contrasted sediments. The lamination of the gneisses affords a frequent strike, which usually runs parallel to the ridges, but the dip is extremely variable, as shown by a study of the signs upon the maps. The evidence leading one to ascribe many of the valleys to faults may be briefly summarized as follows:

1. The "passes," such as Indian Pass, Avalanche Pass, Wilmington Notch; the one at Cascadeville, between Keene and North Elba; the one north of Big Pitchoff mountain, two miles north of Cascadeville; the one southeast of Chapel pond on the road from Beedes to Euba Mills (see the map of Keene for these last three); the one near Crawfoot pond in western Moriah; the cliffs along the north and south sides of Ensign pond, western Moriah, and many other narrow gorges with precipitous sides, evidently produced by fault scarps with a talus. Often a stream forms a waterfall in a specially narrow gorge and the crushed and strained rocks are shown in excellent exposure. Such is Split Rock falls in southern Elizabethtown, where the anorthosite is cracked into smaller, irregular fragments, closely packed together. This crushed zone or shear-zone has probably been a specially vulnerable point of attack for agents of erosion.

2. Many ridges have a comparatively abrupt face on one side and an even ascent on the other. Split Rock ridge in Westport and Essex is a good illustration. Next the lake it is very steep, while on the west the ascent is gradual. Barton hill at Mineville is strikingly of this character. Best of all is the magnificent fault scarp five miles long or more, that begins in Moriah and runs southwest through Crown Point, passing east of Hammondville and ending in Knob mountain whose vertical cliff rises on one side of Knob pond. If one climbs any of the hills in central Moriah and looks westward the horizon line of the mountains is a saw-toothed profile, with a low ascent and a steep drop, many times repeated.

3. Mining experience in the magnetite beds shows that the ore is often lost under gulches and small valleys. The Cheever mine at Port Henry had this experience. Under a slight valley to the west, the ore was sharply cut off. The No. 7 slope at Hammondville met with the same fate, the ore being cut off by a dark chloritic streak, apparently a trap dike, but shown by the thin section to be a breccia of the walls. Breccias on a larger scale

appear at times in the gneisses. An exceptionally fine exposure of one is just above the station at Hammondville. In this connection the great shear-zone at Avalanche lake, often called a trap dike, may be cited. It was described by the writer in the American Journal of Science for August, 1892.

In many cases these faults afforded a start for lines of drainage which have now worn out the valleys to broad reaches and have masked their origin. The old scarps at present are rounded and worn down. But other causes have at times led to depressions. The areas marked by the crystalline limestone series of the map are for the most part relatively depressed. The central belt of Crown Point is of this character, and is doubtless due to the easier erosion of the limestone and black gneisses or schists. Where these no longer appear we can not well say that they may not have been washed away in the past. Remnants, such as that in Lewis and the one in northern Keene, give this impression strongly. Ice in the glacial period has been a strong factor, for these heights of land must have been a great center of radiating ice streams.

A word should be said of the ponds and lakes. The whole region is plentifully sprinkled with these and to them it owes much of its charm of scenery. Many are in the narrow fault valleys and at the head of small lines of drainage. Hardly one of the "passes" referred to above is without such. Many of present existence, or whose record alone remains to us in abandoned "lake bottoms" with side deltas, were backed up by the drift of the ice age. The Elizabethtown valley, well described by H. Ries (Trans. N. Y. Acad. Sci. XIII. 107, Nov., 1893) from observations made during our field work, is of this character. We also see them, as in the case of Ensign pond in western Moriah, passing into swamps and bogs either from the cutting out of the barriers, and consequent draining, or from the encroachment of weeds and sediment, as outlined by C. H. Smyth, Jr., for lakes on the southwestern side of the mountains. (Amer. Geol. XI, 85, Feb., 1893.) When the contour maps are all available some extremely interesting work will be possible upon these problems. Avalanches have been the cause of some lakes in the narrower valleys. The Cascade lakes in western Keene are divided by just such a mass of debris. Chapel pond in the southeastern portion of the same town presents the remarkable case of a pond held in by a narrow ridge of loose materials, just the other side of which is a smaller pond forty or fifty feet lower down. Their outlets join at a still lower point.

Many of these valleys must have been outlined in pre-Cambrian times, for we find in instances the remains of Potsdam sandstone as little areas, far back from the Champlain valley. Such appear in Crown Point and Ticonderoga and are brought out strongly by the map. They usually lie along some present stream, whose valley is now largely filled by drift. We have even found in one or two cases little patches, too small to map, in isolation from any other exposure. The contour maps, when ready, will enable us to draw some interesting conclusions about the present altitudes of these above Lake Champlain and about the earlier spread of the Potsdam, where it has now been washed away.

Schemes of Classification.

In describing the "Primary" rocks of the Adirondack region, Emmons, in 1842, speaks of the following varieties, of which those in italics are cited as occurring in Essex county.

I. Unstratified: a, *Granite;* b. *Hypersthene rock;* c, *Primitive limestone;* d, Serpentine; e, Rensselaerite.

II. Stratified: a, *Gneiss;* b, *Hornblende* (i. e. hornblendic gneiss); c, Sienite; d, Talc or steatite.

III. Subordinate: a, *Porphyry;* b, *Trap;* c, *Magnetic oxide of iron;* d, Specular oxide of iron.

Emmons says little of the respective ages of the subdivisions, and while we must pay a well-deserved tribute to the great industry and ability that he displayed, he yet had some conceptions of these rocks which we do not hold to-day. Thus we would not consider the limestones as igneous rock, nor class with the "Primary," porphyries that penetrate the Utica slate.

Dr. T. S. Hunt described, in 1871, the Mineralogy of the Laurentian limestones (Twenty-first Ann. Rep. N.Y. State Mus. Nat. Hist., p. 47), but said little of stratigraphical moment. Prof. James Hall read before the American Association at Buffalo in 1876, a paper on the Age of the Serpentinous Limestones of Northern New York, of which but a brief abstract was printed. Prof. Hall speaks of them as later than the Laurentian and earlier than the Potsdam. In 1879, C. E. Hall wrote upon the Laurentian Magnetic Iron Ore Deposits in Northern New York. (Thirty-second

Ann. Rep. N. Y. State Mus. Nat. Hist., 133–140.) Mr. Hall's classification is as follows:

I. Lower Laurentian Magnetic Iron Ore Series.

II. Laurentian Sulphur Ore Series.

III. The Crystalline Limestones.

IV. The Labrador Series or Upper Laurentian with Titaniferous Ores.

The relations of II and III are said to be uncertain, but later in a note, III is said to be later than IV.

T. S. Hunt, in 1883, described the crystalline limestones near Port Henry as a great calcareous vein in highly inclined Laurentian gneisses, fragments of which it includes (Canadian Naturalist, 2nd Series, X, 420). Many others have written of the petrography or of minor features, and their papers will be found cited in the bibliography given above, but as they do not relate to stratigraphy they are not mentioned here. Reference must be made also to the admirable work of Profs. Brainerd and Seely on the Chazy and Calciferous, less noted here because this report deals more especially with the crystallines.

In 1890, C. D. Walcott accompanied R. Pumpelly and C. R. Van Hise from Fort Ann to Westport and thence westward toward and to Mt. Marcy. In the words of Van Hise "the peripheral area of this part of the Adirondacks was found to be a great series of laminated rocks, consisting for the most part of white and red regularly laminated gneisses, very frequently garnetiferous, and in lesser quantity, of garnetiferous quartz schist, crystalline limestone, graphitic gneiss, and beds of magnetic iron ore, dipping as a whole at a rather flat angle toward the east and southeast. The garnetiferous quartz schists were found in rather persistent beds. Below the crystalline limestone is a coarse, black, hornblendic gneiss, the contacts between it and the limestone being of the most extraordinary character. The plane between them is one of great irregularity. In the limestone are contained numerous fragments and even great boulders of the gneiss, and also for a distance of some feet away from the contact are numerous crystals of feldspar. The appearance is such as to suggest very strongly that here is an unconformable contact, the limestone being deposited along an encroaching shore line. The phenomena are, however, probably due to the breaking up of layers of gneiss and veins of pegmatite by powerful dynamic movements. In passing from Westport, within a short distance appeared coarse gabbro, which continued as far as the region was penetrated near to Mt. Marcy. This rock in the interior is generally massive, but on its outer border grades into a regularly laminated rock, in exposures very closely resembling the laminated gneisses. The whole is, however, clearly an eruptive rock. Granite was seen locally associated with the gneisses." (Bulletin 86 U. S. Geol. Survey, p. 398 and 33–34, by Van Hise. See also Pumpelly, Bull. Geol. Soc. of Amer., II, 218, 1890.) The writer has not studied with care the region outside of Essex county, but if the above reference to the contacts between the crystalline limestones and the black hornblendic gneiss includes the exposures on the lake shore just above Port Henry, the gneiss can be traced directly into massive olivine gabbro, and the contact is regarded by him (J. F. K.) as an eruptive one, the gabbro being later. Subsequent dynamic disturbances have mixed them up, and especially stretched away from the parent gabbro-ramifying apophysæ.

C. H. Smyth, Jr., in a recent paper on the Geology of Gouverneur, on the western side of the mountains, mentions I, basal gneiss which is associated with igneous granite; II, crystalline limestone with some black schists at its base, but without serpentinous limestone, and above this the Potsdam. (Trans. N. Y. Acad. Sci., XII, 97, Feb., 1893.)

Before leaving this brief statement of previous attempts at classification, reference should be made to the arrangement generally accepted in Canada, which dates from Logan's Report for 1863. The Laurentian is divided into, I. The Ottawa or Fundamental gneiss of all varieties of orthoclase-gneiss, often quite massive in character; II. The Grenville series of crystalline limestones, quartzites, amphibolites, garnetiferous gneiss, and other minor varieties; III. The Upper Laurentian or Norian series of igneous rocks, members of the gabbro family. (See F. D. Adams, Neues Jahrbuch, Beil. Band VIII, 421–427, 1893, and Journal of Geology, I, 325.)

In the following report much the same general division is made as this one of Logan, for it is most nearly applicable, although evidence regarding the succession is not easily attainable. As before stated, this is rather a report of progress than a final word on the subject, and deals with the stratigraphy of the most difficult district. The best exposures of the gneiss and crystalline limestone series will be met in the country more remote from the Norian. It is not certain that we have the Ottawa gneiss, for our gneisses have magnetite beds which in Canada are limited to the Grenville series.

We have; I. A gneiss series consisting of orthoclase gneisses, usually laaminated, but at times quite massive. They almost always contain quartz. There are varieties with hornblende, biotite and with almost no dark silicate, but one of the commonest of all, and that chiefly associated with the Moriah magnetites, contains an emerald green monoclinic pyroxene. Faint pink garnet is occasionally met. The orthoclase is almost invariably microperthitic. Plagioclase is frequent but is subordinate. Quartz may largely fail and aggregates of orthoclase, brown hornblende and pyroxene, with subordinate plagioclase result, as in the great gneiss ridges that enter southeastern Ticonderoga from the south.

The rocks are red and gray in typical specimens, and in those lacking dark silicates even very light colored. In the more basic varieties they are darker and dioritic in appearance.

The rocks of this series contain the workable iron ores.

II. A series of crystalline limestone, ophicalcites, black hornblendic-pyroxenic schists and thinly laminated garnetiferous gneisses. Great pegmatite veins are a frequent associate of these rocks. The limestone beds are sometimes quite thick, 50 to 100 feet, as in Port Henry, but they are seldom continuous for any great distance and are broken by great horses of silicates with very complex aggregates of minerals. The alternation of the limestone with the black schists is often many times repeated. Ophicalcite is abundant in Moriah. Coccolite is a characteristic associate, and granular masses of pyroxene are often met. Graphite is nearly universal. Scapolite is a common mineral in the black schists. The beds give every evidence of intense dynamic disturbances and have often suffered from the intrusion of gabbros, if, indeed, the black schists themselves are not metamorphosed gabbro-sheets. Quartzite, or any related rock, has thus far not been met, unless the granulite of the Weston iron mines in Keene be considered such. Granulite is here used in the German sense and the rocks are practically identical with the Saxon ones.

III. A series of rocks of the gabbro family, ranging from pure aggregates of labradorite, through varieties with increasing amounts of dark silicates, to basic olivine-gabbros. The varieties rich in feldspar are here called anorthosite, following the Canadian practice, in which country these rocks are strongly developed. The basic varieties are called gabbro. This group has been previously called labradorite rock, hypersthene rock, norite (this most commonly in New York State), etc., but the first is not a good rock name, and as for the terms involving hypersthene, microscopic study proves this mineral to be much less common than either green monoclinic pyroxene or hornblende, and much of it seems to be of secondary origin in the "reaction series" around olivine. The rocks of this series have in almost all cases suffered severely from dynamic disturbances and few exposures fail to reveal it. The pure anorthosites have the large labradorite crystals crushed around their edges and appearing only as nuclei in the midst of this breccia. They are especially developed in the interior mountains. The varieties provided with dark silicates often have a gneissoid structure from the alignment of these in streaks. The pyroxene in such cases has largely given way to hornblende and around both, often replacing them almost entirely, are rims of garnet. The dark olivine gabbros have never-failing reaction rims around the olivine and pyroxene, and often pass into thinly laminated gneiss. This gneissoid development occasions the great stratigraphic difficulty of the region, for while the typical representatives of both series I and series III are readily recognized, the gneissoid varieties of the latter are very difficult to classify. They occur as intruded sheets in the gneiss, now infolded in its mass, as dikes and as great outlying knobs and masses. They also penetrate the limestone series, and have powerfully metamorphosed its beds.

The petrographic characters of these gabbroitic rocks as shown along the lake front, have been described by J. F. Kemp in Bulletin V of the Geological Society of America, Boston meeting, December, 1893.

The rocks of this series contain the titaniferous iron ores.

IV. A series of palæozoic sedimentary rocks, whose oldest member is the Potsdam sandstone of the upper Cambrian, and whose latest member thus far identified is the Utica slate of the Lower Silurian

The Potsdam is a somewhat calcareous gray quartzite, sometimes sparingly provided with fossils. It often shades imperceptibly into the Calciferous. The work of Brainerd and Seely has shown the Calciferous to be of unsuspected thickness It involves five divisions, all of which are displayed near old Fort Ticonderoga. They are mostly limestones, involving a layer of fine-grained sandstone between the second and third. No effort has been made to subdivide this formation in our work. Above the Calciferous lies the Chazy, with three divisions, according to the same authorities. It begins with a thin, slaty sandstone and terminates with a thin, fine-grained sandstone, but is otherwise limestone. No attempt to subdivide this has been made. Over this is the Trenton, of black limestones, both well bedded and shaly, and rich in fossils. Still higher, the Utica slate terminates the palæozoic series. Our stratigraphic determinations in the field were checked by identifications of the fossils by Mr. Gilbert van Ingen, assistant in charge of the geological museum at Columbia College, who made a trip to the region, at my request, for this purpose. All these sediments are conformable and were deposited in continuous series. They have suffered minor faulting in post-Ordovician (Lower Silurian) time, but the great disturbances that have chiefly affected the first three series, were completed before their deposition. They have low dips, generally to the north or northwest, and they are illustrated in their relations by our shore sections. Everything indicates that their inclined condition is a remote and fading result of the upheaval of the Green mountains.

It is remarkable that we do not find some trace of pre Potsdam strata, which are so abundant in Vermont, but none have yet been met.

V. A subordinate series of igneous rocks that now form dikes and one notable laccolite, and that are later than the Utica slate. These consist of feldspar porphyry, which is best developed in Essex and Willsborough, and of basic dikes mostly diabase that are very widespread and are everywhere met. The porphyries form a great laccolite at Cannons Point, south of Essex, and appear at various points as dikes as far north as Willsboro' Point. The diabase and related camptonites are found all along the shores, in almost every iron mine in the country, in the Norian mountains (one was discovered well up toward the top of Mt. McIntyre), and at various limestone or other quarries. They furnish an easy mark for erosion, and have served to direct not a few streams. Such is the case opposite Cascadeville, in Keene; in the falls of the Ausable just above Keene Center; at the falls of the west branch of the Ausable in Wilmington notch, and in a small cascade on Mt. McIntyre. The general features of these igneous rocks, have already been described at length by J. F. Kemp and V. F. Marsters, in Bulletin 107 of the U. S. Geol. Survey, an abstract of which appeared in the Transactions of the New York Acad. of Science, XI, 13, 1891.

VI. *The glacial and post-glacial deposits.*— These are very widespread, and where sandy, they give the country the aspect of the sea-shore. There is some coarse, unsorted, morainic material, but the chief accumulations are deltas, lake-deposits, and clays. The first two are best shown in the interior valleys, and of all such phenomena no finer examples could be desired. Near Lake Champlain, the well-known clays are present in great force, and most of the shore country, covered on the map by the little circles, is buried in these clays. At times they hide ideal glaciated surfaces of Calciferous limestone, so that scratched specimens can be obtained, which are the best the writer has ever seen. This is especially true of the shore ledges in northeastern Crown Point. We paid only general attention to them, but could not well help being struck with the abundance of pebbles of Potsdam, high up on the gneissic ridges. Such were found on Bulwagga mountain, on the road from the lake to the Coot Hill mine.

Stratigraphical relations of the above series.— The rocks of series V, as stated, are of quite universal distribution, penetrating all the others. Those of IV are limited to the Lake Champlain shore, and in Essex county extend at most but three or four miles back, as in the case of the Potsdam sandstone in Ticonderoga, Crown Point and Chesterfield. The remotest one is in the first named. It is seven and a half miles from Lake Champlain, and undoubtedly the remnant of a strip that set back through Crown

Point, up the valley of Penfield's Pond into central Ticonderoga. In southeastern Moriah township the Potsdam reaches an altitude of 600 feet above tide. The rocks of III from the high peaks of the interior, where in the group about Mt. Marcy they have their greatest development. They extend to the north, however, beyond the limits of Essex county, for A. S. Eakle has mentioned them near Upper Chateaugay lake (Amer. Geol., July, 1893, p. 32), and N. L. Britton has noted their presence at Lower Saranac lake, just west of the Essex line in Franklin county. (Trans. N. Y. Acad. Sci., Vol. V, p. 72, 1886.) Prof. Cushing has also found gabbro along the line of Beekmantown-Altona, northwest of Plattsburgh. The tracing of the northern and western limits of these rocks will be a most important and interesting addition to our knowledge.

The evidence of their intrusive character and later geological age than I and II, may be summed up as follows:

A. They are composed of minerals characteristic of the gabbro-group. They exhibit a massive habit in the larger mountain masses, where they find their best and least altered development. The anorthosites or richer feldspathic varieties are somewhat abnormal when compared with gabbros the world over, but are practically identical with those of Canada, where these rocks have an even greater development than in the Adirondacks. In the same ridge we find the typical anorthosites and basic olivine-gabbros as phases of the same magma (Split Rock mountain).

B. Except where a gneissoid facies has been developed, they exhibit typical granitoid structure, and a gradual passage may be traced in the same mass from this into the gneissoid type. The latter is chiefly found in the outlying ridges.

C. The smaller outliers are basic gabbro, but as they are just the same rock as the more basic developments in the main masses, we are justified in grouping all together as a single geological unit. These outliers penetrate the gneisses and crystalline limestones as dikes, of no great width, in Ticonderoga (near Long pond, Spec. 365, 352, 346, 347), as numerous knobs in many localities, and as great intrusions of especial interest just north of Port Henry. At the Cheever mine the typical massive gabbro, underlies the normal gneiss which forms the footwall of the ore upon which, after a hanging wall of gneiss, is found the crystalline limestone series, 200 and more feet thick. The same gabbro to the south shows a marked, irregular and nearly vertical contact with the limestone, and just north of Cheever dock abuts against a strongly brecciated outcrop of gneiss. In section GG of the Westport map, the gabbro outlies the gneiss, and in section AA of the Lewis map, it is both over and under the latter. On the highway from Beedes to Euba Mills (Keene map) the massive anorthosites have, in two places, inclusions of a very finely crystalline rock consisting of quartz, orthoclase and garnets, which is much the same thing as the granulites of Saxony. The only other place in which this rock is met is at the western iron mine in Keene, where it is interbedded with ophicalcites. (See section BB of Keene map.) A drill hole was sunk on the east side of Mt. Tom, Mineville, in the summer of 1893, which penetrated 206 feet of gravel, 186 feet of hornblende-orthoclase gneiss, 173 feet of pyroxene-orthoclase gneiss, twenty-eight feet of a crushed and strained quartz-plagioclase aggregate, with very little hornblende, seventeen feet of a coarser variety of the last, with some orthoclase and considerable lean ore, six feet of pure ore, 217 feet of gabbro in which the hole stopped. The writer is indebted to Mr. S. B. McKee, engineer of the mining companies for the drill cores. Mr. F. S. Witherbee also informs me that in sinking their O'Neil shaft (which lies east of Barton Hill) they encountered, about 300 feet from the surface, a three feet vein of magnetite with about 20 per cent $Ti\ O_2$, which is appropriately called the "Humbug vein," while near it and lower is the Smith vein of good ore. Titaniferous ores are invariably in the rocks of series III, and this bed indicates an intrusion of these gabbros. Both these occurrences give also a good illustration of the complexity of the stratigraphy, especially when heightened by infoldings and stretchings.

D. It has been generally supposed that the Norian series (III) forms a great nucleus with the gneisses and crystalline limestones on the flanks. This is well expressed by Van Hise in the quotation given above. It is in a measure true, that we have a great mountain group around Mt. Marcy which consists of these anorthosites with no gneisses yet recorded near. But as we leave this region toward the east and north, the anorthosites and gabbro tend to form ridges, with the series I and II in the valleys and extending well up into the interior. Some ridges of anorthosites are typical outliers and separated entirely from the interior masses. A moment's study of the Elizabethtown, Lewis, Essex, Willsborough and Chesterfield maps will bring this out forcibly. The parent, plutonic magma developed not alone the central group of mountains but sent out great offshoots, at times to very considerable distances. We can only await with great interest the results of further exploration on the west and south, and the description of the relations of the three series which will be there brought out.

The stratigraphic relations of I and II are less easy to demonstrate. Sections BB, CC, DD, and EE, of the Moriah map endeavor to reproduce the conditions met. In each case there was a fault scarp and valley to complicate matters, but in BB the limestones rest on what is regarded as a thin representative of the gneisses which lies over and under the ore. In section EE, the limestones appeared to rest to the southwest on gneiss that showed some distance away. The small exposures near the Pilfershire mine in Moriah appeared to rest conformably on the gneiss containing the ore. The large gneiss exposure in central Crown Point appeared to have a different strike and dip from the limestone series at a distance, but the recorded points are so far apart that little dependence is to be placed on them. With limited exposures and the danger of regarding a gneissic bed that is in the limestone series itself as the fundamental gneiss, such evidence is not easy to procure. None the less the impression remains very strongly after the field work that the same relations hold as have been observed in Canada. The same difficulties are met there. (See F. D. Adams, Journal of Geology, I, 330, 331.) Probably in New York in the counties more remote from the anorthosites, and even in Essex county with more detailed study and exploration, greater certainty may be reached. The writer did not feel justified in giving the necessary time to these obscure local questions until the larger territory had been once gone over and recorded. With a wider experience and a knowledge of the crucial localities, this second stage of the work can be entered and more light may be thrown on them. The separation on the map is chiefly based on lithological criteria, which are always to be viewed in a conservative spirit. It is quite possible that all these gneisses are to be classed in the "Algonkian" of the geologists of the United

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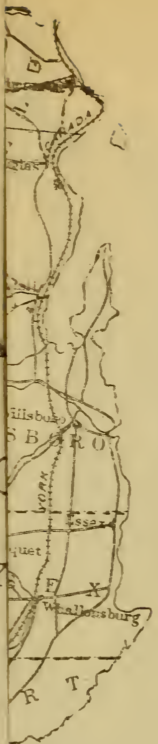

MAP

OF

ESSEX COUNTY,

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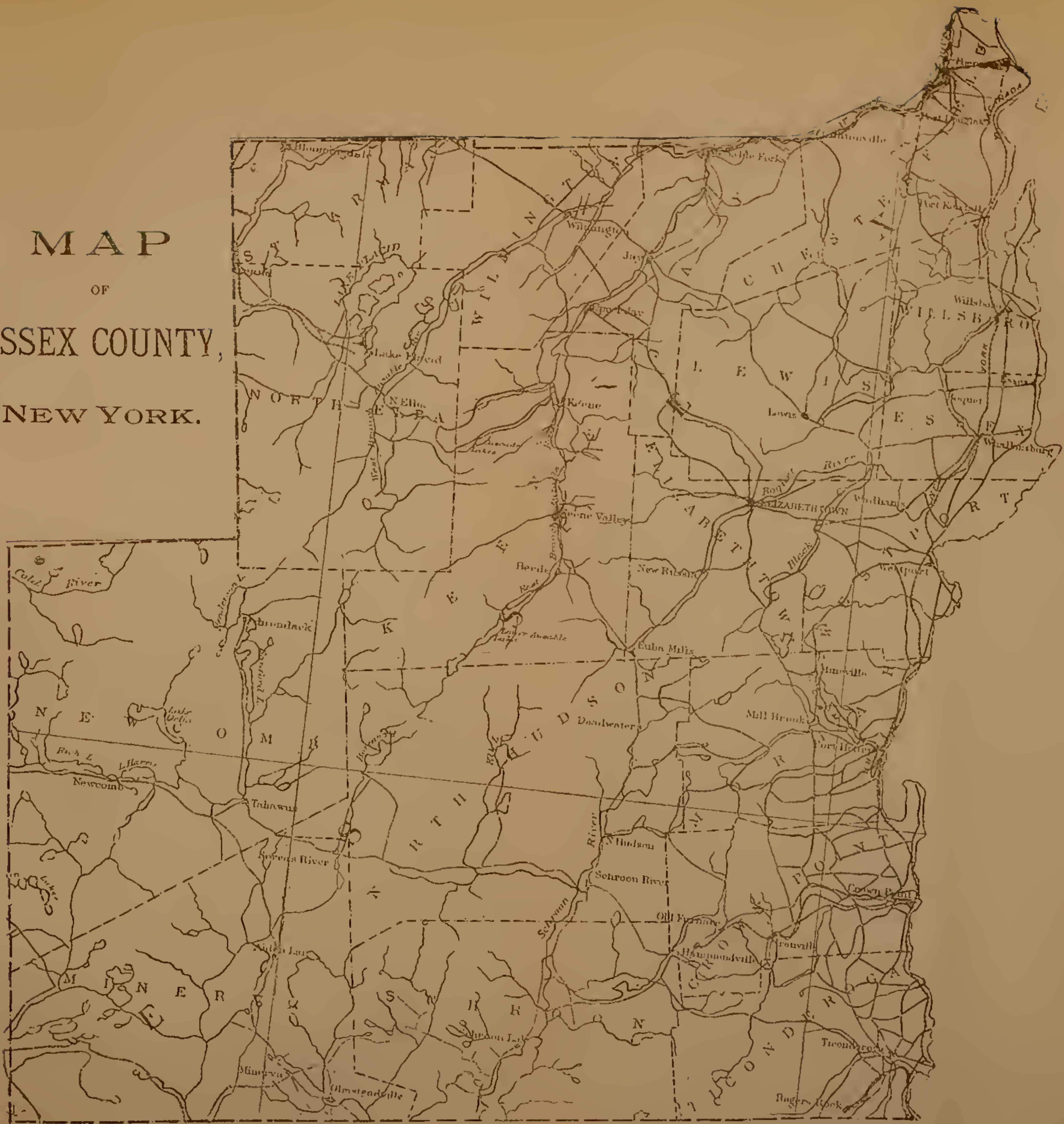


States Survey. The crystalline limestone series certainly is, and has been so colored by Walcott in a small map of the United States. (U. S. Geol. Surv. Bulletin, Plate II, p. 365.) The magnetites occur in gneisses as fundamental as any, and these gneisses show more or less mineralogical variety. Such ores and variable gneisses are thought to characterize the Grenville series in Canada while the Ottawa gneiss is very uniform and lacks ore entirely. Van Hise regards the Grenville series as Algonkian. (Bulletin 86, U. S. Geo. Surv., p. 497.) Whether, therefore any gneiss has been yet met in this district which would be regarded archæan in the sense of Van Hise, or which would correspond to the Ottawa gneiss of the Canadian geologists, is doubtful. Dr. Smyth, however, has perhaps met these older gneisses on the western side, as they are there more uniform and lack magnetites. (See the Trans. of the N. Y. Acad. Sci., XII, 101, 1893.) His work and the writer's have proceeded in close association.

The geology is next described by townships. Those treated are in alphabetical order:

TOWNSHIP GEOLOGY.

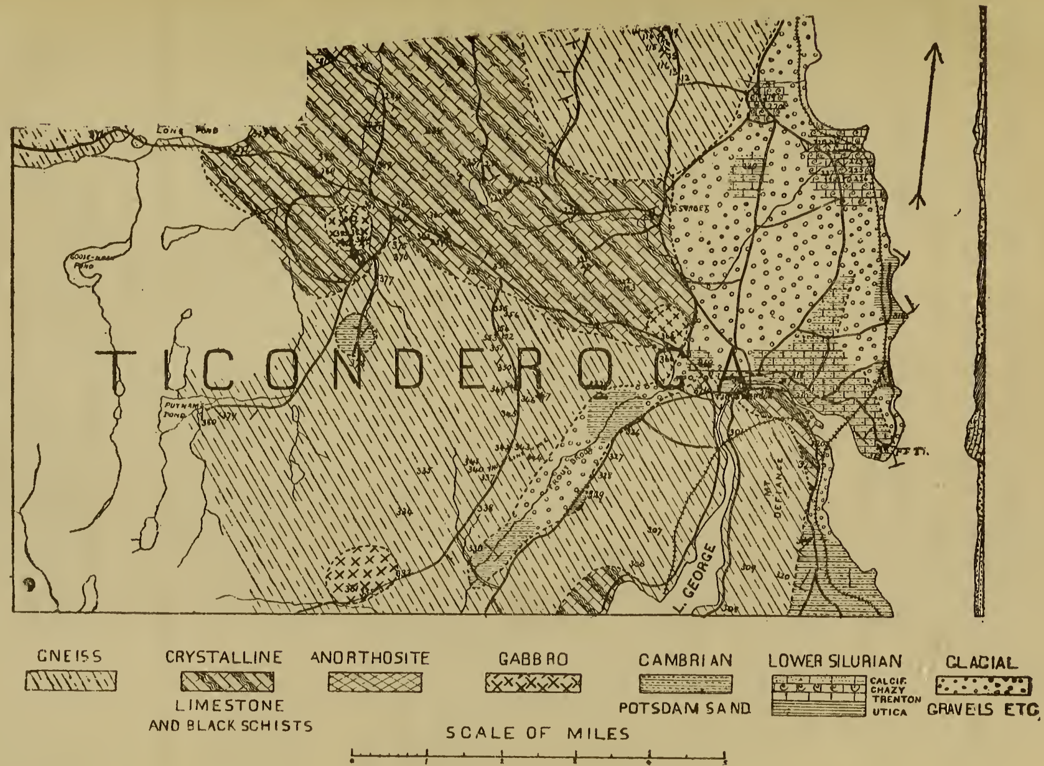
TICONDEROGA.

Series I. The gneisses make up the largest portion of Ticonderoga. They enter from Warren county on the south as high ridges with a northeast trend. They probably form the western part of the town, but the area is a wild region and can best be reached from the west another season. The strike of the laminations in Ticonderoga village is north thirty degrees east, but in the ridge west of Lake George it is north forty degrees west. Further north it changes to the east again and near Putnam's pond is variable through ninety degrees, but has a general northerly trend.

As a general thing the gneiss is quite basic, and has but little quartz in these exposures in the south. It is dark and dioritic in appearance, but in thin sections the feldspar is found to be microperthitic orthoclase. The dark silicate is commonly hornblende, and with it in some is more or less pyroxene. Quartz is subordinate, but always present in slight amounts. Apatite, zircon, magnetite, the usual accessories are present. Good examples of crushed and strained crystals are occasionally met. Along the highway where specimens 338–355 were gathered, there is a fine fault and crushed strip. Out west of Long Pond there is a very light-colored acidic gneiss, precisely like the wall rock of the one at Hammondsville, and one of the drill cores cited earlier from Mineville. It contains chiefly quartz and plagioclase with which a few shreds of a bluish hornblende are associated.

In the northwestern area of gneiss we have at 12 a pink gneiss with biotite, quartz, microcline and orthoclase, but at 13 a gray variety with quartz, plagioclase, orthoclase, abundant green pyroxene, and but little hornblende. At the iron mines, the wall rock contains hornblende, biotite, plagioclase, a little quartz, and magnetite (115). This area forms a high knob, known as Buck mountain. The principal elevation is west of the iron mines, but a very considerable spur lies to the eastward, the highway near the mines being in a depression. The strike of these gneisses is chiefly east and west, and they have a steep, southerly dip. They are in bold contrast in this respect to the other areas, north and south.

Series II. The crystalline limestone series has its greatest development in Ticonderoga, and the adjoining parts of Crown Point, so far as the county has been yet seen. The whole northern central portion of the former consists of this series. The white beds of marble are not of great width or length, as a general thing. They are closely involved with dark schists or gneisses that show under the microscope, common hornblende, pale green pyroxene, occasional biotite, frequently scapolite and subordinate plagioclase. These weather readily to rusty exposures, and this, combined with the easy erosion of the limestone, makes the topography less elevated than it is with the gneisses and anorthosites. Still there is a great deal of garnetiferous gneiss also involved in this area, and some outcrops that are shown by the thin sections to be


TICONDEROGA
LONG POND
GOOSE-NECK POND
PUTNAM POND
L. GEORGE
MT DEFIANCE
GNEISS
CRYSTALLINE
LIMESTONE
AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF.
CHAZY
TRENTON
UTICA
GLACIAL
GRAVELS ETC.
SCALE OF MILES

indistinguishable from the older series. The outcrops were, however, so involved, that on a map of this scale they could not be distinguished in the drawing without undue confusion. There is a great deal of pegmatite in the form of granitic veins in this series II, and the veins are often met throughout the area and are quite characteristic. They show, in their section, beautiful microcline, plagioclase and quartz. The famous graphite mine that has made this town a well-known source of this mineral is on a vein of this character. It is situated at 121, about three miles northwest of Ticonderoga village on Chilson hill. It is a true fissure vein that cuts the lamination of the gneiss walls at nearly right angles. The wall rock is a garnetiferous gneiss, with an east and west strike, and the vein runs at the "big mine" north twelve degrees west and dips fifty-five degrees west. There are two principal openings, the "big mine" so-called at 121, and the "little mountain" workings at 122, and many smaller ones, but all have been long abandoned. The vein filling was evidently orthoclase (or microcline) quartz and biotite, with pockets of calcite. Besides the graphite, it contained tourmaline, apatite in fine prisms, pyrite, and sphene. F. L. Nason has also recorded enormous crystals of pyroxene. (Bull. 4, N. Y. State Museum, p. 12, 1888.) The graphite must have reached the fissure as some volatile or liquid hydrocarbon, such as petroleum, and have become metamorphosed in time to its present state.

A great pegmatite vein occurs in the rocky cliff, a little way northwest of the steamboat landing at Delano. It is just west of a high fence that protects the roadway from the cars. In certain portions it is abundantly charged with allanite.

Brecciated gneiss of great perfection occurs in the northwestern portion of this area at 387 and 389.

Series III. The gabbros are represented, so far as yet discovered, by three small outliers, but there are doubtless others which may be noted hereafter. The one near the town, at 365, is a typical gabbro, of massive habit. It contains labradorite with abundant inclusions at the centers of the crystals, faint green monoclinic pyroxene, a little brown hornblende and biotite as runs around magnetite, dodecahedral and irregular garnet, which at times replaces the twin lamellæ of the labradorite. The area in the southern central portion, 331, is a large mass not entirely fresh, and showing hornblende, pyroxene, plagioclase and a little biotite. In the northwestern area a most interesting intrusion is met, that differs from anything elsewhere noted. A mass of very coarsely porphyritic rock, with feldspar phenocrysts two to three inches in diameter in a ground mass of hornblende and plagioclase, has penetrated the limestone series. The phenocrysts are aggregates of smaller individuals, now much altered. The entire intrusion is at least twenty feet thick, but there are other parallel dikes a few feet distant, which are less. No. 346, three miles away, is a narrow one, which, while showing a dioritic mineralogical composition and structure, is yet of the same general type as the gabbros.

Series IV. All the divisions of the palæozoic as before referred to are represented. The most interesting of all is the Potsdam sandstone, because of the little remnants which now remain at the heads of the two inland valleys. The one away up in the central part of the town is the most isolated outcrop we have seen, and as stated earlier, is probably the surviving remnant of a tongue which extended southward from Penfield pond. When the contour maps are available, it will be interesting to determine the relative altitudes and the maximum movements which the Potsdam has suffered. The exposures along Trout brook are of the same character, and they indicate that the valley is a pre-Cambrian depression. The Potsdam again appears southwest of Mt. Defiance. It is succeeded to the north by the Calciferous which is much faulted. The Calciferous extends well back of Ticonderoga village, but in the village, along the river, the Potsdam shows beneath it. The Utica slate forms two miles of shore above the old fort.* North of this the Chazy is again developed both near the shore and inland. A small patch of Calciferous likewise shows at 230.

Series V. No representative of this series was found.

Series VI. The glacial and post-glacial deposits are quite extensive, especially along Lake Champlain. The latter are clays, and mask the geology to a great extent. C. E. Hall speaks of a great moraine near Putnam's pond, and explains Lake George as

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* For detailed geology of the area for a mile or two around the old fort and to the south, see Brainerd and Seely, Bull. Amer. Mus. Nat. Hist., June, 1890, III, p. 10.

due to a dam of drift. We have not examined this carefully, but in the Ticonderoga river, much of the descent is over rocky ledges, so that drift is not the sole cause.

Mines.— There are two openings on Buck mountain, but both have been long shut down and are now full of water. Prof. Smock has recorded that the ore strikes north thirty degrees east and dips fifty-two degrees northwest. It was mined to a depth of 132 feet with an average thickness of sixteen feet. He states that the ore yielded 54 per cent of iron, with a little sulphide, but the old dumps now show a good deal of the latter. The operating company was the Lake Champlain Ore and Transportation Company, but the mine was called the Vineyard. Although long known, it was opened in 1887. One or two small openings are strung along the same belt. Prof. Smock* also records a hematite vein eight feet wide in Mt. Defiance, on the Lake Champlain side. This was opened in 1888, and mined to a small extent. In the present condition of the iron business there is little chance of these mines resuming.

The graphite mines have already been mentioned. Their activity ceased many years ago. There is, however, a graphite mill and dressing works in Ticonderoga, which purifies the product of a deposit in Hague on Lake George. Its output goes to the Dixon Crucible Company.

Crown Point.

Series I. The Buck Mountain gneisses extend into Crown Point as two tongues separated by a depression which is filled with drift. They show the same general characters as in Ticonderoga. Pyroxene gneisses form no small part of the exposures. Thus a red massive gneiss (No. 8) has microperthitic orthoclase, quartz, microcline, plagioclase and emerald green pyroxene, and the same mixture repeatedly appears elsewhere. It is closely involved with biotite-gneiss (No. 10). At the old eupyrchroite or apatite mine, of which Emmons in 1842 made quite extended notes (Nos. 11 and 28), there is a well-developed crushed and faulted strip. The mines at Hammondville afford fine exposures of the gneiss in the southwestern part of the town. It is an extremely acid variety and, although consisting of

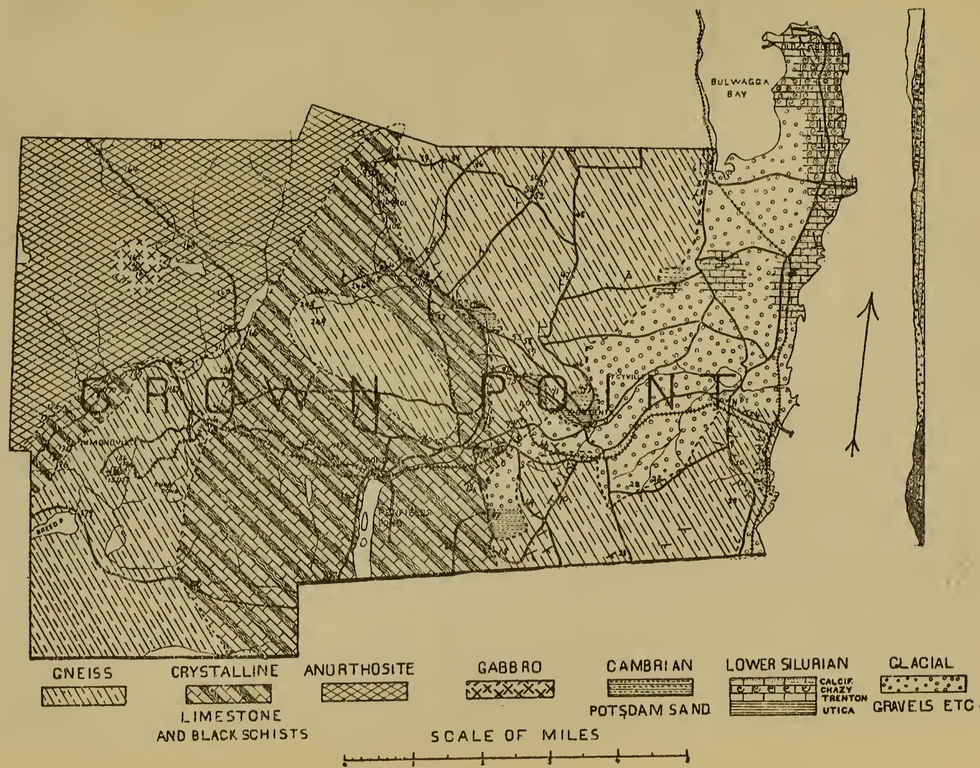
* Bull. 7, N. Y. State Museum, June, 1889, pp. 24-25.

quartz and plagioclase, it has but a few scattered shreds of bluish hornblende to represent the dark silicates. Near the ore beds occasional garnets appear, and these in the drill cores are regarded as a favorable indication. This rock lacks foliation almost entirely and would be at once called a very acid granite, without microscopic examination. We have only met it in this area, and in a Mineville drill core which was earlier cited. This rock is extensively faulted and superb breccias are to be had just north of the railway station. The gneiss is crushed into fragments of all sizes and cemented by chlorite and other decomposition products. Faults are not infrequent in the mines and give great trouble, often cutting the bed completely off. Here, as was mentioned earlier, gulches are very bad for its continuance. In No. 7 slope the ore was lost at one of these friction breccias (which was quite naturally regarded as a trap dike until seen in thin section), and a drill hole over a thousand feet deep failed to find it on the other side. This famous old group of ore bodies deserves detailed study and plotting, but as the mine maps were destroyed in a fire some years ago, it would be a long task to accumulate the necessary data.

The gneiss is sharply cut off on the east by one of the finest fault scarps in the entire region. From Knob pond it bears away with a general course of north thirty degrees east, for over five miles, and everywhere is marked by a vertical cliff, or where this has weathered, by a crushed strip. It brings the limestone series against the gneisses and norite.

In the middle of the great limestone area, we so frequently met heavy, massive gneisses, that we were driven to the conclusion that the lower series comes to the surface. It is inclosed by the limestones, black schists and gneisses. No. 76, at the southern end, is biotite gneiss with abundant allanite.

Bulwagga mountain extends down from Moriah, affording the gneiss area of the northeast. It contains the usual variety of pyroxene, hornblende and biotite gneisses. The general strike of the laminations is nearly north and south. In the northwest corner of the area along the east and west road (88, 89, etc.) the rocks seem to afford an imperceptible gradation from the typical light-colored gneisses, into the dark basic ones of the limestone series with limestones, and thence into gneissoid forms of anorthosite.


BULWAGGA BAY
CROWN POINT
GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF.
CHAZY
TRENTON
UTICA
GLACIAL
GRAVELS ETC
SCALE OF MILES

The limits of each are beyond accurate mapping, so that one is forced to conclude that the limestone series is an upper phase of the gneiss and that both are involved with intruded anorthosites.

Series II. The limestone series forms the central part of the township and its most fertile portion. The topography is diversified, but not on so grand a scale as among the gneisses and anorthosites. The country is mostly tilled and not left to forest growth. The beds of limestone are frequent, and in not a few cases they have been opened to supply flux to the early charcoal furnaces and the modern anthracite stacks. In the eastern edge of the northern portion of the area, near 101, a superb pegmatite vein has been opened, known as Roe's spar bed. A breast of 150 feet or so of coarsely crystalline orthoclase and quartz, with occasional great bunches of biotite, has been exposed by workings long since abandoned. Three narrow trap dikes cut the breast, and along one of them are developed the curious tourmaline crystals, described many years ago by E. H. Williams. (Amer. Jour. Sci. iii, XI, 273, 1866.) The quarry cannot be far from the borders of the gneiss, but the country is very wild and wooded.

A narrow belt of the limestone series begins in the western part of the town and runs in a valley between gneiss on the south and anorthosite on the north, into Schroon township.

Series III. The anorthosites and gabbros find their only development in the northwest corner, where they form a rugged and mountainous ridge known as Moose mountain. It is a prolongation southward of a still larger mountainous mass in Moriah. The area marked with the gabbro sign is a very basic development but is the characteristic aggregate of green monoclinic pyroxene, brown hornblende, labradorite, magnetite and garnet. It contains two deposits of titaniferous ore, which have been prospected to some little extent. The ore was very low in phosphorus and sulphur, as is usual in these titaniferous ores, but the titanium prevented its utilization. So far as prospects showed, the ore was a mass in the midst of igneous rock, that formed its walls. The anorthosites are often, if not almost always gneissoid, but they are unmistakable in their characters. Labradorite is the principal mineral, and then follow hornblende, pyroxene, and garnet.

Series IV. The Potsdam sandstone is traceable some miles up the stream valleys, as is graphically shown by the map. The small patches that rest on the gneiss northwest of Crown Point Centre are curious and interesting little remnants, over which the creek now tumbles in cascades. The Calciferous sandstone forms a small patch on the southeastern lake shore, and then north of the steamboat dock it appears in great force, until it dips under the Chazy limestone, which, at the end of the point, in turn passes below the Trenton limestone. Brainerd and Seely estimate the Chazy as 305 feet thick. (Bull. Geol. Soc. Amer., II, 300, 1891.) In the deep railway cut at 2 on the map, by pacing and calculating on the dip, I estimated that 350 feet of cherty blue limestone of the Calciferous were exposed, with five feet of slate about 100 feet above the base of the exposure. This is division A of Brainerd and Seely, and its general thickness for the region, they estimate at 310 feet. These cherty limestones are devoid of fossils. Under the microscope the chert is seen to be perfectly amorphous (colloid) silica, set with innumerable rhombs of calcite, but with no sponge spicules or any trace of organic life.

This section is one of the best in the Champlain valley, for the Siluro-Cambrian rocks, as the faults are practically absent and the series is conformable from the Potsdam into the Trenton. No Utica slate is, however, met on the east shore above Ticonderoga until we reach Essex.

Series V. The dikes are represented by diabase. Three are found in No. 7 slope at Hammondville. One crosses the highway east of Breed's pond in the western part of town (179), another appears near the railway, northwest of Penfield's pond (80, 81), another is due north of this (at 68) and three cut Roe's spar bed (101) due north of the last, near Moriah. Undoubtedly there are many more not exposed.

Series VI. The quaternary deposits are mostly clays along the lake and these have a great development. They rest on wonderfully glaciated limestone. The principal scratches run north twenty-eight to thirty degrees east but another set is north twelve degrees east. Westward from Crown Point village, terraces and deltas of post-glacial sands and gravels are widely developed and would well repay study. The contour maps are needed for this.

Mines.—The iron mines at Hammondville have ranked with those at Lyon mountain and yield only to the Mineville deposits in production. They are chiefly bessemer ores, of about 50 per cent iron. The leaner ores have been concentrated at Ironton on the railroad to Crown Point, where there is a water power. The principal ore body is the old Penfield bed, which has been operated in recent years from the opening known as the West End. This has furnished a vast quantity of ore, for while in general much thinner it has yielded in places a breast from twenty feet six inches to thirty feet across. It strikes about northeast and dips southeast. The dip is very irregular, beginning in the west end with forty-five degrees it soon flattens to about five degrees and then rolls abruptly over to sixty degrees. The bed also drops away to right and left, as one descends, having thus a very curious roll, or dome-shaped outline. Swells of ore run into the foot, and smaller veins offset in the same direction. These small offsets are shot ore and very low in phosphorous. The wall rock is a granitic aggregate, as stated above, of quartz, and plagioclase, very light colored and with the merest shreds of hornblende and a few garnets. There are innumerable other openings in the vicinity, some very small, and mere pockets, others, as No. 7 and the Hammond Hill, mines of good size. Faults, and attendant breccias are well developed, and the accurate structural geology would require very careful and detailed work. So far as noted by us the wall rock is the same. Additional notes on these mines will be found in Smock's Iron Mines in the State of New York. (Bull. 7, N. Y. State Museum, 1889, and in Putnam's report in vol. XV, of the Tenth Census, p. 116.) One or two other little openings have been made south of Hammondville, and the titaniferous ore of Moose mountain has been already cited.

Roe's spar bed, mentioned earlier, may be again referred to. For some years it supplied potteries to the south with large quantities of feldspar. Its remote situation militates against it, necessitating too much carriage, but there is an indefinite amount of the mineral. Reference should be made to the old phosphate mine, about a mile and a half south of Crown Point village, from which Emmons named the mammilated phosphorescent variety, eupyrchroite in 1838. (See Second Ann. Rep. N. Y. State Survey, p. —; Final Report on the Second District, 1842, p. 286; Beck's Report on the Mineralogy of N. Y., 1842, p. 240; C. T.

Jackson, Am. Jour. Sci., ii, XII, 73; Forbes' Phil. Mag., iv, XXIX, 340; W. P. Blake, Trans. Amer. Inst. Min. Eng., Feb., 1892.) Blake states that it occurs along the contact of a dyke of greenstone with Laurentian gneiss, but we found no trap. It is rather along a crushed or faulted strip, with a little crystalline limestone forming one wall, and the principal veinstone a mass of chloritic alteration products, through which are distributed, brown tourmaline and quartz. The eupyrchroite was early exhausted. Reference may also be made to a small prospect southwest of Crown Point station on the Delaware and Hudson railroad, which yielded some years ago a few small garnets.

Essex.

Series I. The gneiss does not appear in Essex.

Series II is represented by a small exposure of crystalline limestone. etc., at Split Rock. The limestone is, however, so thickly filled with bunches and contorted streaks of silicates, as to be almost inferior to these in amount. A fine metamorphosed dike cuts its northern face at a low angle. The limestone series is soon succeeded to the south and west by the anorthosites and gabbros to whose contact influences it doubtless owes its great amount of contained silicates.

Series III covers the greater part of the town. It is partly the extension of the Split Rock ridge from Essex, partly the isolated knob of Boquet mountain, and partly lower hilly exposures. It is quite possible that from Whallonsburgh, south into Westport, there may have been an old palæozoic channel. Petrographically these rocks are anorthosites, more or less gneissoid.

Series IV. The Calciferous sandstone does not appear. The Potsdam sandstone forms a fringe along the anorthosites, and the Boquet river flows just along east of the contact. The Chazy limestone is brought up in the southern part of the village by a superb pair of faults, so that it forms a high bluff. It is a drab fossiliferous limestone. There is a difference of displacement in the faults, for on the north the Trenton is at the water's edge, while to the south is the Utica. Both show fine exhibitions of the dragged edges of shaly or slaty strata against a firmer resistant bed. This fault was figured fifty years ago by Emmons, and is one of the most conspicuous features along the shore. The Trenton limestone, more


ESSEX
CANNON'S POINT
SPLIT ROCK
PORPHYRY
WHALLONSBURGH
GNEISS
CRYSTALLINE
LIMESTONE
AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND.
LOWER SILURIAN
CALCIF.
CHAZY
TRENTON
UTICA
GLACIAL
GRAVELS ETC
SCALE OF MILES

or less shaly, and very fossiliferous, runs along the water to the north, with practically no dip. The Utica slates extend south from the fault for two miles, and then after a low drift-covered break, are found against the Split Rock anorthosites, up to 100 feet above the lake.

Series V. The dikes and porphyries find their best development in this region. At Cannon's Point there is a fine laccolite of feldspar porphyry, of which Emmons gave a sketch and description. (Geol. 2nd Dist., p. 85.) The sheet is a thousand feet long or more, lies interbedded in the slates, with many apophysæ, and forms a high cliff. It has an excellent trachytic structure, lacks dark silicates almost entirely and is a curious and interesting rock. It is described at length in Bulletin 107 of the United States Geological Survey. Strangely enough it has exerted almost no effect on its walls. Other outcrops appear to the northwest and two large dikes cut the banks of the lake to the south. A most interesting camptonite dike cuts the faulted block of Chazy limestone, and appears in the quarries to the west. Several basic dikes pierce Split Rock, and a single small one was met on Boquet mountain.

Series VI. Between the Potsdam fringe and the lake shore the rocks are buried beneath the sands and clays of the Potsdam. T. G. White, of my party, discovered a few marine shells south of Cannon's Point. Much drift is met in the western part of the town. Wells near the Essex railway station have shown the clay to be over sixty feet deep.

Mines and quarries.—There are no mines in Essex. For rough masonry, the Chazy beds back of the village afford excellent stone and have been worked to a considerable degree. A quarry has also been opened along the lake shore, near the contact with the Utica slate.

Willsborough.

Series I. No gneisses appear in Willsborough.

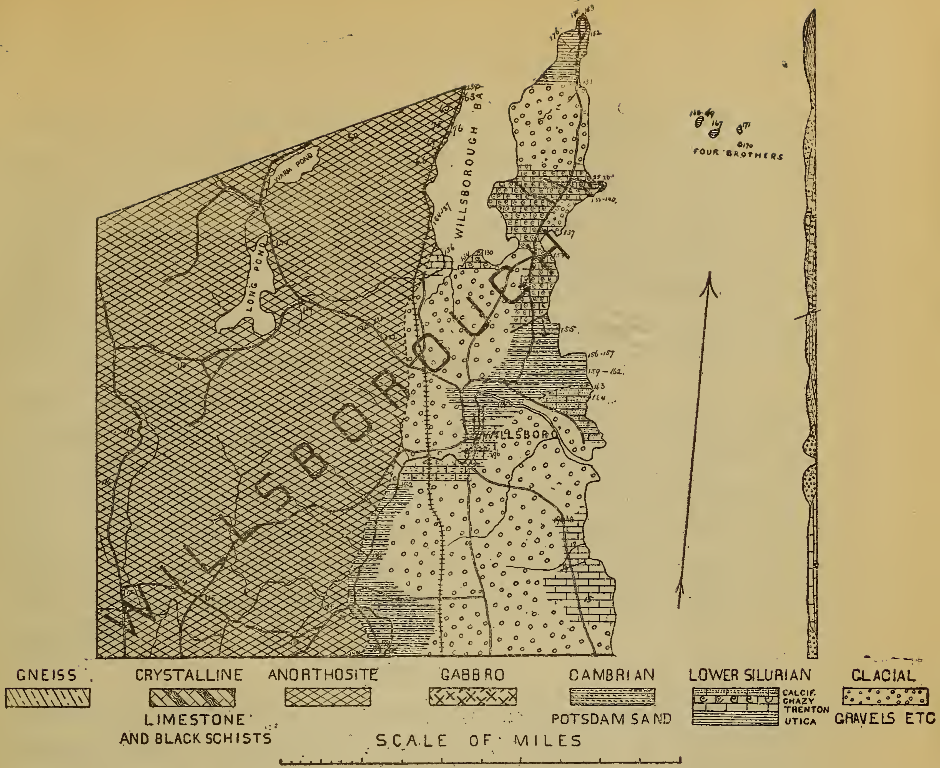
Series II. In the cuts of the Delaware and Hudson railroad along Willsborough bay, a small showing of ophicalcite appears, apparently an inclusion in the anorthosite of Trembleau mountain. The igneous rock shows just over it.

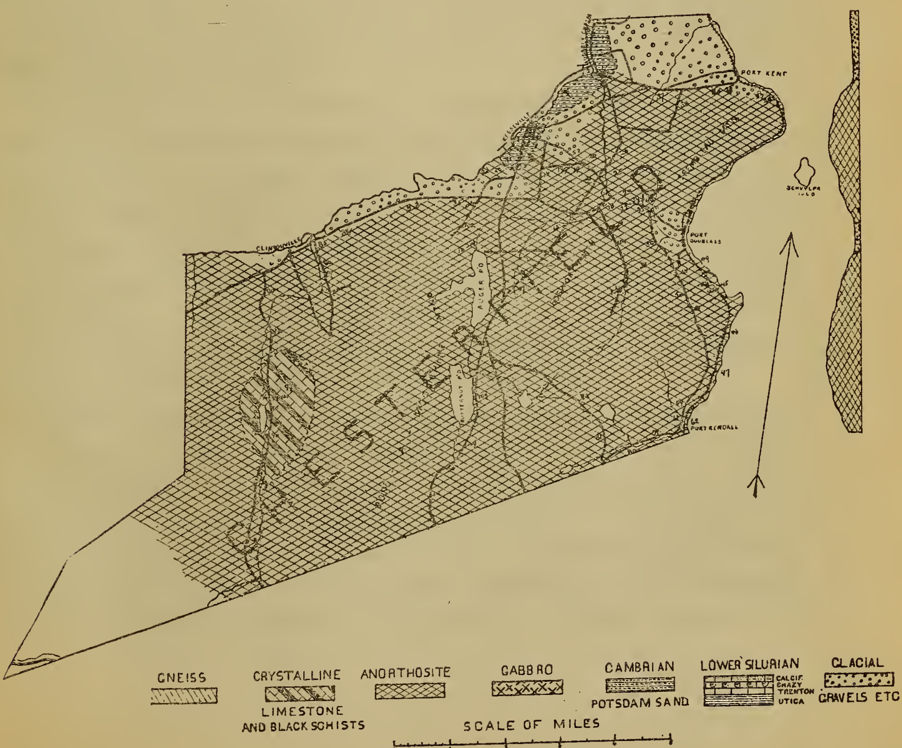
Series III. The anorthosites cover all the western portion, and are of the usual type, meriting no special description. Somewhere in this area is the vein of wollastonite, garnet and hornblende referred to by Emmons (Geol. 2nd Dist., p. 286) and Beck (Mineralogy of N. Y., p. 270.) The wollastonite was analyzed by Vanuxem. (Jour. Phila. Acad. Sci., II, 182, 1822.) The vein is said to be in gneiss, which probably means gneissoid anorthosite. The minerals suggest the presence of at least a fragment of crystalline limestone. As we did not happen to notice the record of the occurrence until our return, it was not investigated.

Series IV. All the palæozoic members, from the Potsdam sandstone to the Utica slate, are represented in Willsborough. The Potsdam forms a fringe on the anorthosite ridges along the Boquet river, and in its exposures to the eastward bends with it so that it appears in the village of Willsborough in fine ledges. It is soon afterward buried in the heavy sand beds at the river's mouth, but is seen on the lake shore to the north. It is so soon succeeded by the Chazy limestone that a fault is unquestionably present. The Calciferous sandstone overlies it in a small area on the south. The Chazy appears at the base of Willsborough Point and about half way down it. It has been opened for building stone in Clark's quarries and was in former years the basis of a very large industry. The stone was called Champlain blue stone and had a high reputation. To the north it runs under the Champlain clays and the next rock exposure is of Utica slate at the end of the point. This is the only outcrop of this formation except the little areas on the Four Brothers islands. The Trenton appears just north of the Essex line, but is soon buried under sand and clay. Another small exposure outcrops against the anorthosite at the head of Willsborough bay and is rich in fossils.

Series V. The porphyry forms several dikes. Two appear at the quarries on Willsborough Point, and are well exposed, another cuts the Potsdam on the lake shore, about the mouth of the Boquet river.

The diabase dikes are very abundant in the cuts of the Delaware and Hudson railroad on the west side of Willsborough bay. At the extreme end of Willsborough Point five basic dikes cut the Utica slates, and near Long pond, at 124, another cuts the anorthosite.


WILLSBOROUGH BAY
WARM POND
LONG POND
WILLSBOROUGH
WILLSBORO
FOUR BROTHERS
GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF. CHAZY TRENTON UTICA
GLACIAL GRAVELS ETC
SCALE OF MILES


PORT KENT
KEESEVILLE
CLINTONVILLE
PORT DOUGLASS
PORT KENDALL
GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF. CHAZY TRENTON UTICA
GLACIAL GRAVELS ETC
SCALE OF MILES

Series VI. The sands and clays extend north from Essex and form a north and south strip a short distance back from the lake. Evidently in the post-glacial times there was a rather deep arm of Lake Champlain, then standing higher than now, which ran south from Willsborough bay to Split Rock ridge, and which had a great reef of the palæozoic sediments between it and the lake basin proper. Across this reef there were passages or channels at four points. The Boquet river formed a large delta which is now represented by sandy hillocks.

Mines and quarries.—There are no mines in Willsborough. The quarries of Chazy limestone have already been referred to. Forty feet or more of heavy-bedded blue limestone are exposed dipping north seven to eight degrees and striking east and west. Several acres have been quarried over, and one or two men were still working last summer. The business of late years has languished.

Chesterfield.

Series I. No undoubted exposure of Series I was met. There is much rock of a gneissoid character, especially on the northwest, but it all proved in thin sections to contain plagioclase, hornblende and pyroxene, and is, therefore, esteemed gneissoid anorthosite. The gneisses do come in, however, not very far to the west and north of the line.

Series II. This is limited to a considerable area near Trout Pond, and as the rock has been quarried for burning, the exposures are excellent. A quarry face of white, graphitic limestone is opened, which is thickly seamed by bunches of the silicates, pyroxene, hornblende, wollastonite, etc. On the north it is cut by a diabase dike, at which the workings stop. Some ophicalcite also appears. Anorthosite occurs all around it, and to this is doubtless due the great development of silicates in the limestone. No dips and strike worth record are to be noted.

Another most curious outcrop may be noted in this connection. It occurs in the eastern central part of the town from which specimen 55 is recorded. At Buttermilk falls a brook drops about sixty feet over a ledge of anorthosite. On the opposite side of the ravine is a wall whose lower forty feet are anorthosite. Above this is a layer of dense, green serpentine, which is capped by soft, friable sandstone, apparently a little remnant of

Potsdam. Just what the relations of the serpentine are, does not appear, the facts having been noted by my assistant, Mr. Fenner.

Series III. The anorthosites constitute nearly the entire township. They form a great ridge along the lake, known as Trembleau mountain, which is somewhat broken at Port Douglass by a cross valley. In the interior is Bosworth mountain, and back of this the rugged Poke-a-Moonshine ridge. The rocks are green anorthosite in general, often gneissoid. The cuts of the Delaware and Hudson railroad, afford fine exposures along the lake, and the developments in quarries for "Ausable granite," as it is called, near Keeseville give a number of openings. This rich green feldspathic variety contains plagioclase, and green pyroxene with a few shreds of hypersthene, and an occasional garnet. It has proved a handsome building stone, and has found wide use, although at present the quarries are shut down. Along the lake the anorthosites occasionally show crushed strips or shear-zones which have developed a granular mass of pyroxene, plagioclase and garnet, with a somewhat schistose structure. Biotite appears in the southeastern exposures. The gneissoid portions are the usual banded aggregates of hornblende, plagioclase and subordinate pyroxene. In the quarries near Keeseville, quartz can be detected. So far as the lake shore is concerned, the rocks of Series III do not appear again north of Port Kent, but give way to the palæozoic sediments.

Series IV. The Potsdam sandstone is the only member of this series present. It sets back along the Ausable river to a point above Keeseville. In the Ausable chasm it affords one of the finest sections of this formation of the State. Fossils occur, but are not abundant. The small remnant of supposed Potsdam at 55, west of Port Douglass was referred to under Series II.

Series V. An immense number of diabase dikes penetrate the anorthosites along the lake shore, and every railway cut shows them. One was also met in the quarries at the north end of Augur pond (No. 13); another at 16 southeast of Keeseville, and a third in the limestone at Trout Pond.

Series VI. The sands and gravels are best developed along the northern boundary. A fine bank with marine shells (*Saxicava*, etc.) is exposed along the railway south of Port Kent. Much sand appears along the Ausable river and forms banks and terraces that will well merit study in connection with the new contour maps.

Mines, quarries, etc.— No mines of any moment have been opened. The one industry of this character is of recent development and is based on the building stone near Keeseville. The feldspathic anorthosites furnish a beautiful stone when homogeneous and one that takes a fine polish. Prof. Smock has given quite full details of the quarries in Bulletin 3 of the State Museum, p. 33, 1888, and Bulletin 10, p. 232, 1890.

Elizabethtown.

Series I. The gneisses enter Elizabethtown on the southeast, being an extension of the Moriah area, west and north of Mineville. The strike in the southeastern corner is generally northeast, but further on, beyond Lincoln pond, at the Gates mine (45, 46), it is northwest. Down in the Boquet River valley it is again northeast (52). The dip is extremely variable. The gneisses are mostly hornblendic, but they show the invariable microperthitic orthoclase and quartz. Not infrequently malacolite appears with the others. Such rocks form the walls of the Gates ore bed, and are met near the mines of the western edge of the gneiss. Occasional bands of rock, consisting of plagioclase, pyroxene and hornblende, run through the gneiss, as at 40, east of New Russia, and these suggest intruded sheets of series III. The gneiss forms a tongue to the north, along the valley of the Boquet, and finally disappears about a mile south of Elizabethtown village.

Series II. The crystalline limestones and associates are not met in Elizabethtown.

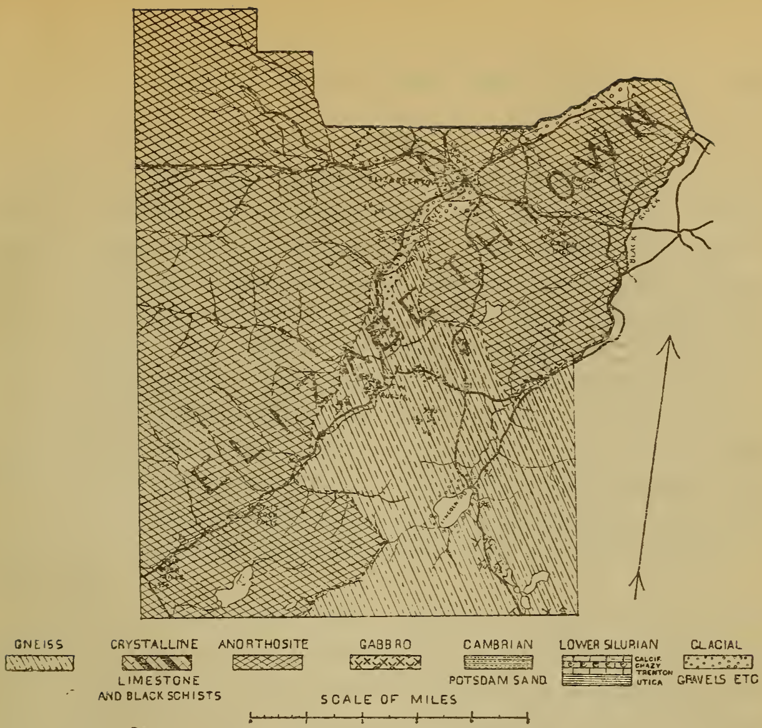
Series III. The anorthosites cover the greater portion of the township. They make up the large hills or mountains, Raven hill and Green hill on the northeast, the great peaks of Hurricane mountain and Giant, on the west, and the lower hills near Euba Mills on the south. They are at times nearly pure, massive labradorite, again and most often, are gneissoid. In Cobble hill near Elizabethtown they are notably so. The basic gabbros were only met as float material but these boulders furnished some excellent illustrations of the variety with olivine. On the road to Lewis very curious narrow veins of garnet cross some exposed ledges. They suggest metamorphosed diabase dikes.

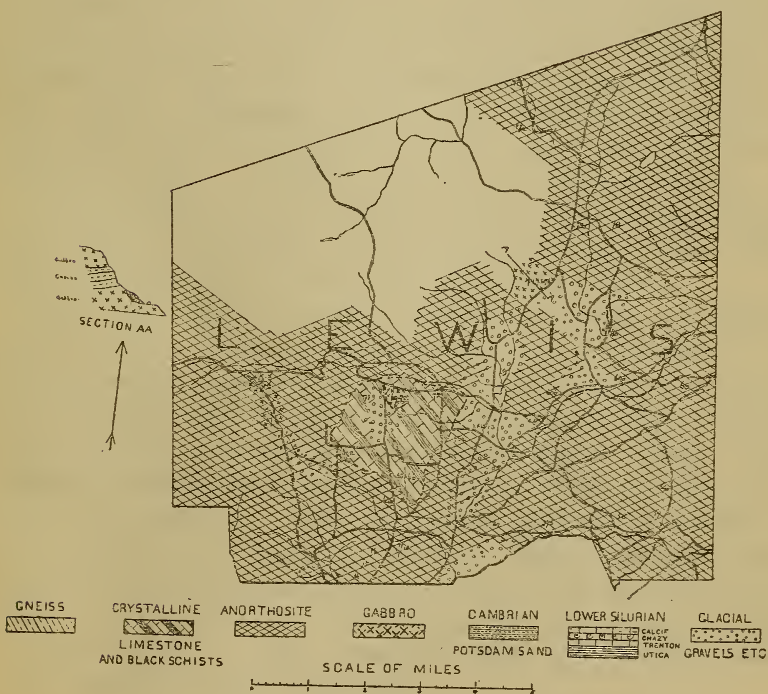
Series IV. The palæozoic sediments are entirely lacking.

Series V. One small diabase dike has penetrated the anorthosites, just above the mill, about one mile west of the Windsor Hotel.

Series VI. The surface deposits are sands and gravels. The central Elizabethtown valley is a beautiful exhibition of an abandoned lake bottom, with well-preserved side deltas. It has been described by my assistant, Mr. Ries, in the Trans. N. Y. Acad. Sci, Nov., 1893, p. 107. The water was clearly held in check by a drift dam, which was finally cut and practically all eroded. The narrow valley, through which the Boquet river makes its exit, furnished an exceptionally favorable position for a barrier. The old deltas are of wonderful perfection, and at the time of our visit the recent freshet exposed them in ideal cross-sections. Lincoln pond is now the shrunken remains of another pleistocene lake, the boundaries of which, however, we have not traced.

Mines.—The decline of the blomaries or forges proved the death-blow to iron mining in this town, except at the Burt Lot mines, which are just within its southern boundaries. They, however, belong with the Mineville openings and are worked in connection with them. They afford a rather lean bessemer ore. On the next great ridge, to the northwest of Lincoln pond, is a line of openings, of which the Gates and Putnam mines are the largest. They are in pyroxene gneiss and showed good sized breasts up to twenty feet, but their remote situation and the closing down of the New Russia blomary ended their production. Titaniferous ores are known in several places in the eastern anorthosite area. Along the western edge of the gneiss, and not far from its contact with the anorthosites is a row of deposits which extend both north and south of New Russia. They are known as the Ross, Post, Castaline and Pitkin beds, and in their day they contributed more or less ore to the New Russia forge Mr. Anthony Ross of Essex, owner of the Ross bed, informs me that the analysis of his ore showed a high grade of bessemer. The remote situation will prove an impassable barrier to the profitable production of these ores for many years.


GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF
CHAZY
TRENTON
UTICA
GLACIAL
GRAVELS ETC
SCALE OF MILES


SECTION AA
LEWIS
GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF
CHAZY
TRENTON
UTICA
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GRAVELS ETC
SCALE OF MILES

LEWIS.

Series I. The only exposure of undoubted gneiss, or of a gneiss consisting of microperthite and quartz, is the peculiar included mass shown in section AA. It is enveloped in gabbro and the component minerals are so shattered that it seems almost elastic and might, were it not for the few large orthoclases that have escaped. It is one of the best examples of the intrusive nature of series III. The roads to the northwestern corner of the town were destroyed by the freshet so that we could not cross that area, but shall reach it from the neighboring town of Jay, which remains to be traversed. There are many gneissoid rocks in Lewis, but they all showed, under the microscope, only hornblende, pyroxene and plagioclase and were, therefore, referred to series III.

Series II. The central area colored for this series is most peculiar. At 63 to 66 it is practically a great ridge of nearly pure quartz. The mineral shows various shades, and outcrops for 2,300 paces across the strike. Some little feldspathic gneiss or pegmatite appears, and a little ophicalcite. The exposure was regarded as a member of series II, which had suffered from excessive metamorphism by contact with the surrounding norite. Probably from this area the wollastonite was derived, which is recorded by the early reports. Pegmatite occurs at 66a. Hornblendic gneiss outcrops at 71, and at 72 graphitic quartzite was found, though not certainly in place. A gabbro intrusion penetrates at 69–70.

These exposures may run further north. The broken bridges cut us off from exploring it as thoroughly as we wished. The northwestern portion is very wild, with hardly a house.

Series III. The anorthosites and gabbros cover the greater part of Lewis. Both are found in excellent development. In the southeastern portion varieties occur which are rich in biotite (59, 59a), and in No. 59 hypersthene is present in large crystals. In the gabbros of the extreme west biotite is also notable. The feldspars contain the numerous inclusions which are characteristic of the gabbros. They are regular geometrical shapes, of more or less perfect hexagonal outline. They are ranged along lines that intersect at sixty degrees, and resemble sagenite nets of rutile. The needles are pleochroic yellow the long way, and colorless the short. The hexagonal scales are probably micaceous ilmenite, and the rods rutile.

Series IV. The palæozoic sediments do not appear in Lewis.

Series V. One small trap dike was met in the bed of a little brook at No. 15, near the southern boundary.

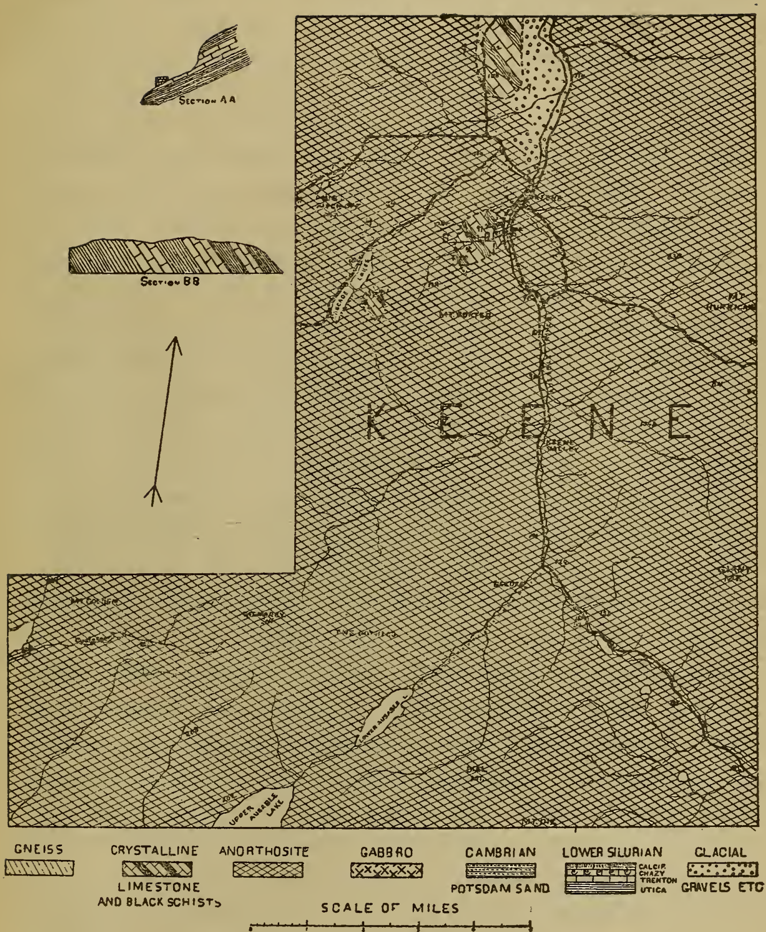
Series VI. Pleistocene sands are very widely spread throughout the town. Its central part is a broad valley, and this is buried under these later deposits throughout much of its extent, more so than the map indicates. These serve to hide the rocks, and it is quite possible that a wider area than is so colored on the map is formed of the Series II and I.

Mines.— We learned of no mines in Lewis. The forge formerly located in the town was supplied from neighboring townships. It would be strange, however, if there were not some deposits of titaniferous ores.

Keene.

Series 1. No undoubted gneisses appear in Keene. In the northern part gneissoid rocks are abundant, and in the field they were regarded as members of this series, but under the microscope they are basic aggregates of hornblende and plagioclase, and contain no orthoclase. They, therefore, were esteemed gneissoid anorthosite. A red feldspathic granite does appear at the falls just above Keene Center (Keene of map), and is of uncertain relations. It was only seen at one other locality so far as our work has gone, and this was at the large falls and flume in Wilmington notch, where, as in Keene, it is associated with a basic dike.

Series II. The crystalline limestones, etc., have two excellent, small exposures and apparently a third which is not well understood. The one southwest of Keene Center covers a square mile or more, on the slopes of the western ridge. It consists of ophicalcite in the main, with large bodies of magnetite, and apparently at the Weston (or Wood) mine with granulite (German granulite) abundantly interbedded. It is the only case in the whole region of the Adirondacks, known to the writer, where there are magnetites in limestone. Section BB of the map is an endeavor to reproduce the rocks as seen in the brook right near the Weston mine. The limestone is thoroughly crystalline and heavily charged with blackish green pyroxene, which has yielded the serpentinous mottlings where weathered. It also contains rude garnets, at times of large size. Some of these are half or


Section AA
Section BB
K E E N E
UPPER AUSABLE LAKE
GNEISS
CRYSTALLINE LIMESTONE AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN POTSDAM SAND
LOWER SILURIAN
CALCIF CHAZY TRENTON UTICA
GLACIAL GRAVELS ETC
SCALE OF MILES

three-quarters pyroxene, and are clearly an alteration product after pyroxene. The iron ore body appears to have been a great shoal, with more or less calcite mixed, but it yielded a very good ore extremely low in phosphorus. The workings on the foot-wall were over 300 feet down. The neighboring Hale mine also revealed a large body of ore, but was less mined. The associated granulite resembles the Saxon augite-granulites. It contains microperthite, green pyroxene, quartz and granet and microscopically is very similar to those of the Saxon "Granulit-gebirge." It is hard to say just what its origin is; possibly it was a shaly quartzite in the limestone series. The strip of this series that enters Keene from the north is very characteristic. A great bed of white graphitic crystalline calcite is interbedded with the familiar pyroxene-hornblende schists, and has coccolite, etc., associated. It was formerly burned for lime.

The little area upon the mountain at Cascadeville we did not explore beyond the iron mine. It afforded in the float beautiful diopside and several other minerals in a limestone. Emmons regarded it as a dike of calcite, intruded in the norite (Geol. 2nd Dist., p. 228), but he then mentions a list of very characteristic contact minerals (pyroxene, idocrase, apatite, scapolite). The mass is doubtless a fragment caught up in the intruded anorthosite.

Series III. The anorthosites cover almost all the township. Indeed the heart of the Adirondack is in its southwestern corner. Mt. Marcy, the Gothic, Mt. Colden and many more famous peaks form a noble group. They furnish anorthosites in their most typical development. Hypersthene is quite common and even on the highest mountains garnet is not lacking. Specimens brought from the top of Marcy reveal it. These rocks are pale blue, light green, and even faintly red. Their general characters have already been outlined. It was from this region that Dr. A. R. Leeds derived most of his material for his valuable paper on their lithology. (Twentieth Ann. Rept. N. Y. State Mus. Nat. Hist., 1876.) It is the best area for typical anorthosites. As stated in the introduction, inclusions of quartz, feldspar and garnet rock were found in the anorthosite along the road to Euba Mills. They are entirely analogous to the typical German granulite, and doubtless are small fragments of some orthoclase rock caught up in the intrusive anorthosite.

The excessively gneissoid phases are found on the north, and their puzzling character has already been referred to.

Series IV. No palæozoic sediments are found.

Series V. Diabase or related dikes are occasionally met. There is one at the falls above Keene Center, that forms the channel of the river for a way. There are others down which the cascade, at Cascadeville, comes tumbling. Evidences of small ones are now and then seen still in remaining boulders. They occur as well in the northern limestone area.

Series VI. The central valley is well covered with drift. It may have been an old lake bottom for a time. Fragments of terraces suggest it.

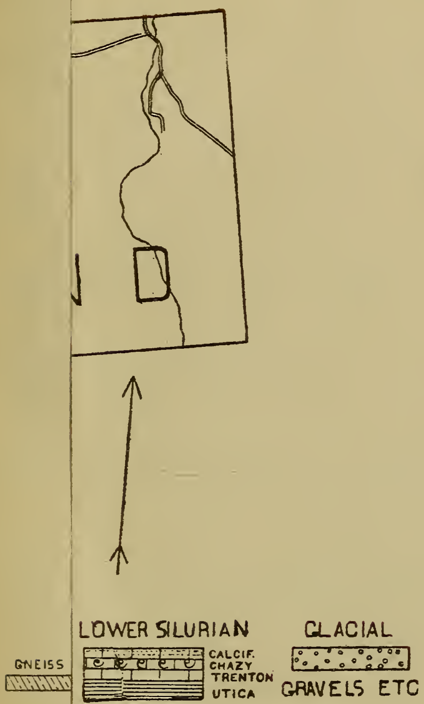
Mines.—The Weston or Wood iron mine, and the neighboring Hale mine are the only ones of any moment. Their geological relations have already been mentioned. They have not been operated since 1880 and probably never will be again. The ore body at Cascadeville is extremely inaccessible, and being in anorthosite would probably prove titaniferous. It is lean and limited.

North Elba.

Series I. A somewhat doubtful area of these rocks appears along the west branch of the Ausable river in the southern approach to Wilmington notch. The rocks are strongly gneissic, and in section are seen to contain much quartz, untwinned feldspar, often coarsely microperthitic, and green pyroxene. They may be an abnormal, quartzose phase of series III. Series III forms the Whiteface ridge to the west and the mountains on the east. Outside the township, at the waterfall in Wilmington notch, there is red granite. Undoubted gneisses just enter the northwest corner near Saranac, but the country is generally buried under sand and few exposures appear.

Series II. No trace of this series was met.

Series III. The anorthosites cover nearly the entire township, the only certain exception being on the northwest. To the south the main peaks of the Adirondacks just cross the town line, and Mt. McIntyre, which is second to Mt. Marcy in height, is within the limits of North Elba. These great hills are massive anorthosite, quite richly feldspathic and not containing many dark silicates. Garnets are occasional, but are most


LOWER SILURIAN
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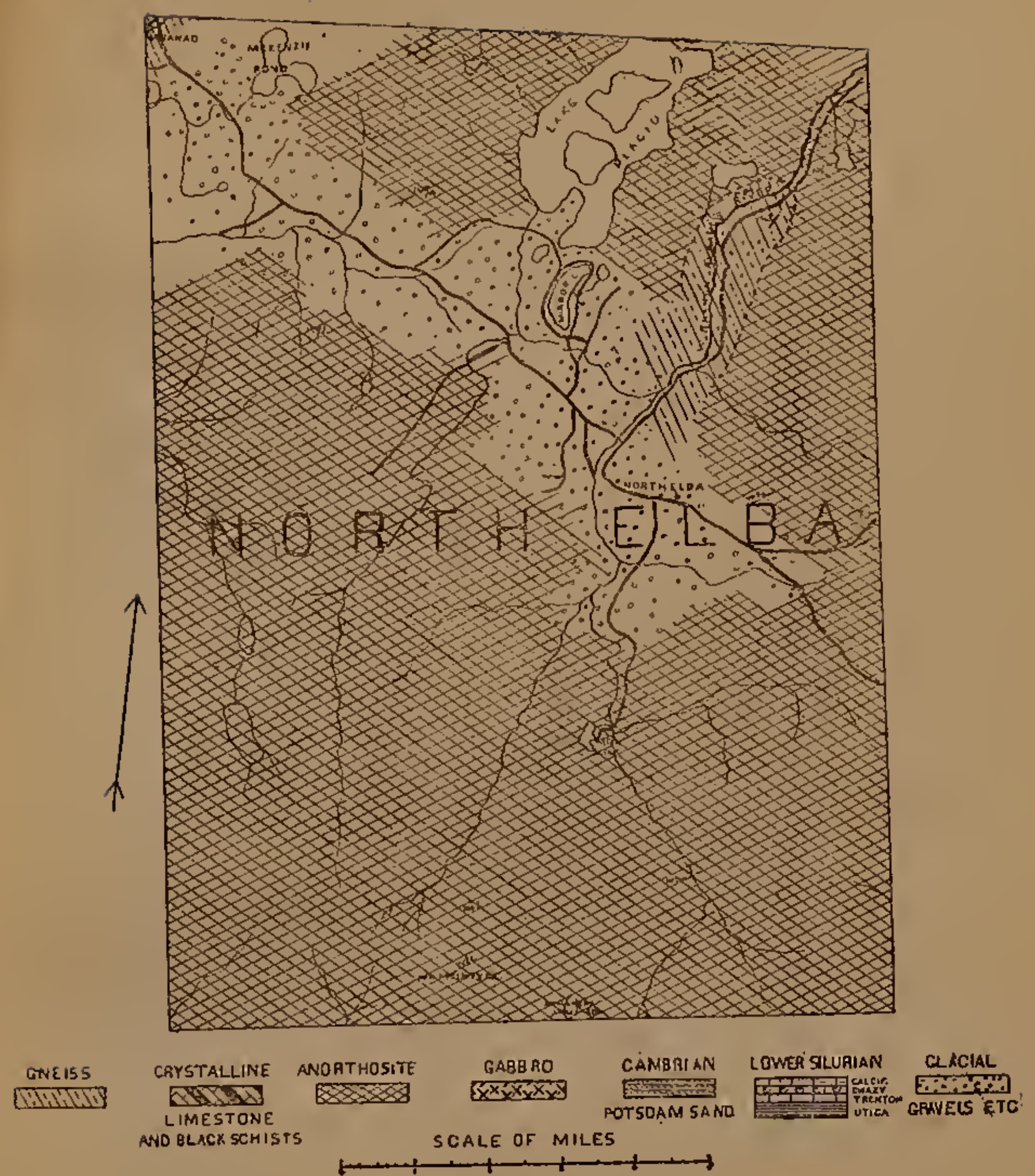
NORTH ELBA
NORTH ELBA
GNEISS
CRYSTALLINE
LIMESTONE
AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
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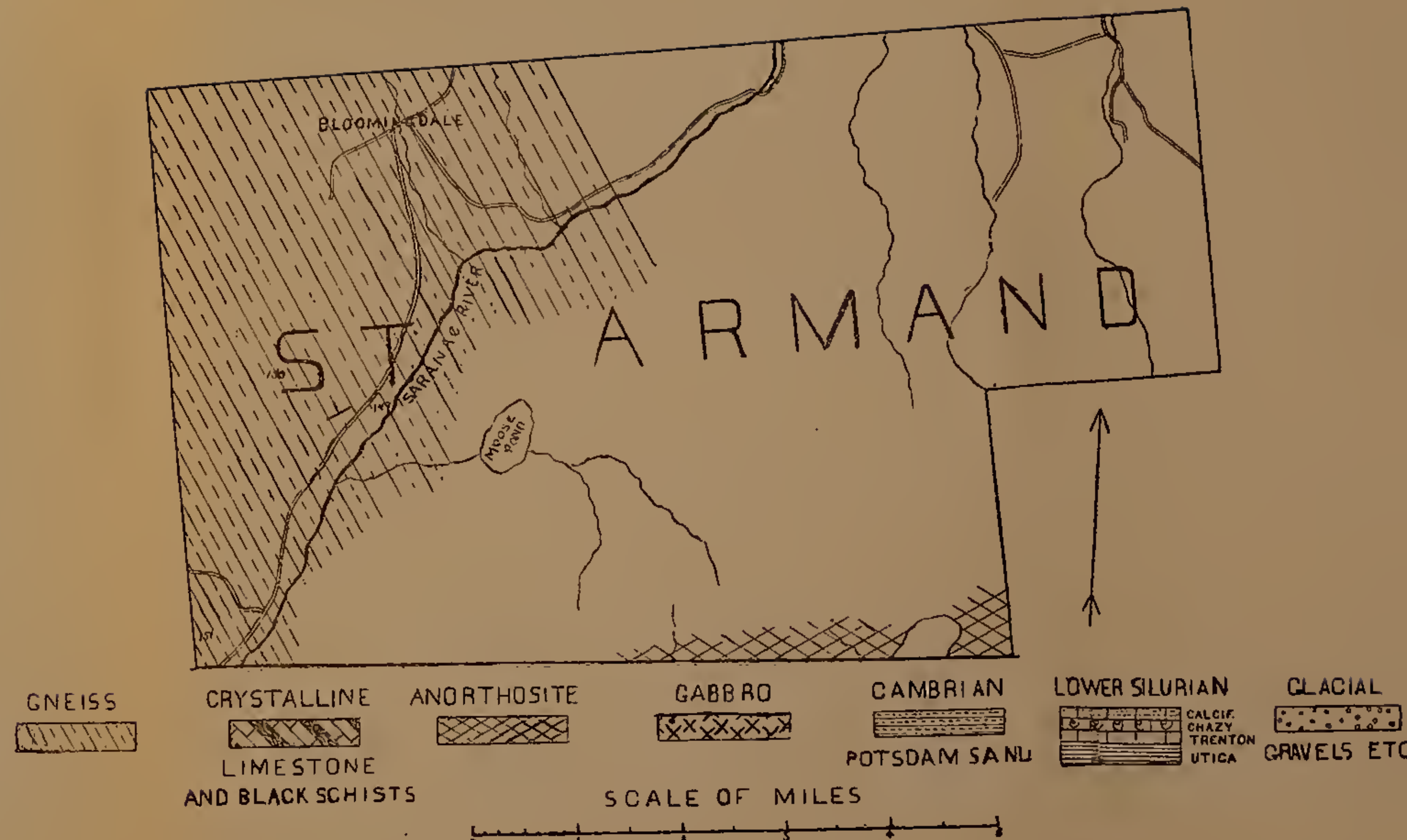
SCALE OF MILES


BLOOMINGDALE
SARANAC RIVER
MOOSE POND
ST ARMAND
GNEISS
CRYSTALLINE
LIMESTONE
AND BLACK SCHISTS
ANORTHOSITE
GABBRO
CAMBRIAN
POTSDAM SAND
LOWER SILURIAN
CALCIF.
CHAZY
TRENTON
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abundant in the more basic developments. The great fault or shear-zone at Avalanche lake, that looks so much like a trap dike, is one of the most interesting places in the mountains. Its minerals are those of the rather basic gabbros, but are much crushed and metamorphosed. It does not show the mineralogy or structure of a dike, and has already been described and figured by the writer. Indian pass, Avalanche pass and Wilmington notch are superb fault valleys. Whiteface is a great anorthosite peak, and various smaller knobs project in the northwestern portion above the widespread gravels and sand.

Series IV. No trace of this series appears.

Series V. The dikes are represented by a few of the diabase type. One occurs in a little cascade on the trail up Mt. McIntyre and a number are just outside the town in Wilmington.

Series VI. A very large proportion of the area, much more than is indicated on the map, is covered by the sands and gravels of the Pleistocene. Fine lake bottoms, deltas and banks of sand are distributed over the lower country. They are especially developed in the west and northwest, so that one may drive miles or tramp through scrubby growth without meeting a trace of a rocky ledge.

St. Armand.

I have only traversed as yet the western part of this town and the adjoining portion of Franklin county. The eastern part is a wilderness formed by the Whiteface ridge and some smaller parallel ones on the west.

Series I. The gneisses in quite typical development form the western portion. Excellent orthoclase gneisses appear on both sides of the road from Saranac to Bloomingdale. In the next county they occur for several miles out from Saranac, along the line of the Chateaugay railroad. Near Saranac, at 151, there is a cliff, showing curiously crushed quartzose gneiss, thickly set with tremolite and phlogopite. It appears to be along a fault cliff, and under the microscope is much strained and crushed. On the west side of the same ridge is a quarry in excellent gneiss, above which is a quartzose bed charged with sulphides, especially pyrite. It is a good illustration of a "fahlband" or bed in gneiss containing sulphide minerals. A few shining flakes of molybdenite aroused the suspicion of silver.

Series II. No evidence of the crystalline limestones has been noted.

Series III. Undoubtedly much of the eastern portion consists of this rock. It will be investigated another season. I was obliged to return October 1st, without investigating it.

Series IV. No palæozoic rocks are present.

Series V. No dikes have thus far been seen.

Series VI. The Pleistocene sands and gravels are well shown, but reach their greatest development near Bloomingdale and further west and north. Bloomingdale station, on the Chateaugay railroad, is outside the township, but is built on a superb lake bottom, over which the track is laid for several miles almost on a dead level. In other respects no developments of special interest were met.

Yours respectfully,

J. F. KEMP.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF CLINTON COUNTY.

JAMES HALL, State Geologist. | H. P. CUSHING, Assistant.

1893.

Preliminary Report on the Geology of Clinton County, N. Y.

BY H. P. CUSHING.

JAMES HALL, *State Geologist:*

SIR.— In 1893 a beginning was made in the work of investigating and mapping the geology of Clinton county. The work done was confined to the eastern half of the county, bordering on Lake Champlain, and the brief time available for work was devoted to a rapid and general survey of the area; detailed mapping on a large scale, which will be necessary in order to accurately map the subdivisions of formations and minor structural features, being left for the future. Over a considerable part of the region covered, outcrops occur only rarely or else are entirely absent. The structure is also complicated by numerous faults, which are frequently difficult to locate from lack of outcrops in sufficient number. The results presented are, therefore, merely tentative. It is believed, however, that the boundaries between the pre-Cambrian and Cambrian, between the Cambrian and the succeeding limestones (Calciferous — Chazy — Trenton), and between these and the Hudson River rocks are accurately presented, except where they can not be precisely located, on account of widespread occurrence of soil and drift. The tentative matters concern in the main the differentiation of the subordinate members of the limestone series (Calciferous — Chazy — Trenton) from one another, and their delineation on the map. To a considerable extent these are also accurately located. Elsewhere much doubt prevails, but it was believed wise to have the map represent the present state of our knowledge.

So far as known the rock terraces underlying this county comprise:

1st, a series of gneisses, more commonly flesh colored and rather acidic, frequently, however, black and basic, rarely quite schistose in structure, and of pre-Cambrian age;

2d, a series of crystalline limestones and associated gneisses, also of pre-Cambrian age;

3d, a mass of coarsely crystalline gabbro or norite, (the anorthosite of Adams), also pre Cambrian;

4th, the Potsdam sandstone, of great but unknown thickness, of upper Cambrian age, overlying unconformably any one of the first three groups;

5th, the sandy dolomites of the Calciferous sandstone, whose thickness in Clinton county is unknown, but which, further south, have a thickness of 1500 feet;

6th, the Trenton limestone formation, locally divisible into the Chazy, Black River and Trenton limestones, readily distinguishable by their contained fossils; the Birdseye limestone, which elsewhere may be separated from the Chazy and Black River, not presenting its distinctive characters in this district;

7th, the Hudson River group, represented at but a single locality by calcareous black slates which carry the fauna of the lower portion of this group, the Utica slate. In the area so far studied and mapped, all these formations are present but the pre-Cambrian limestone, series No. 2.

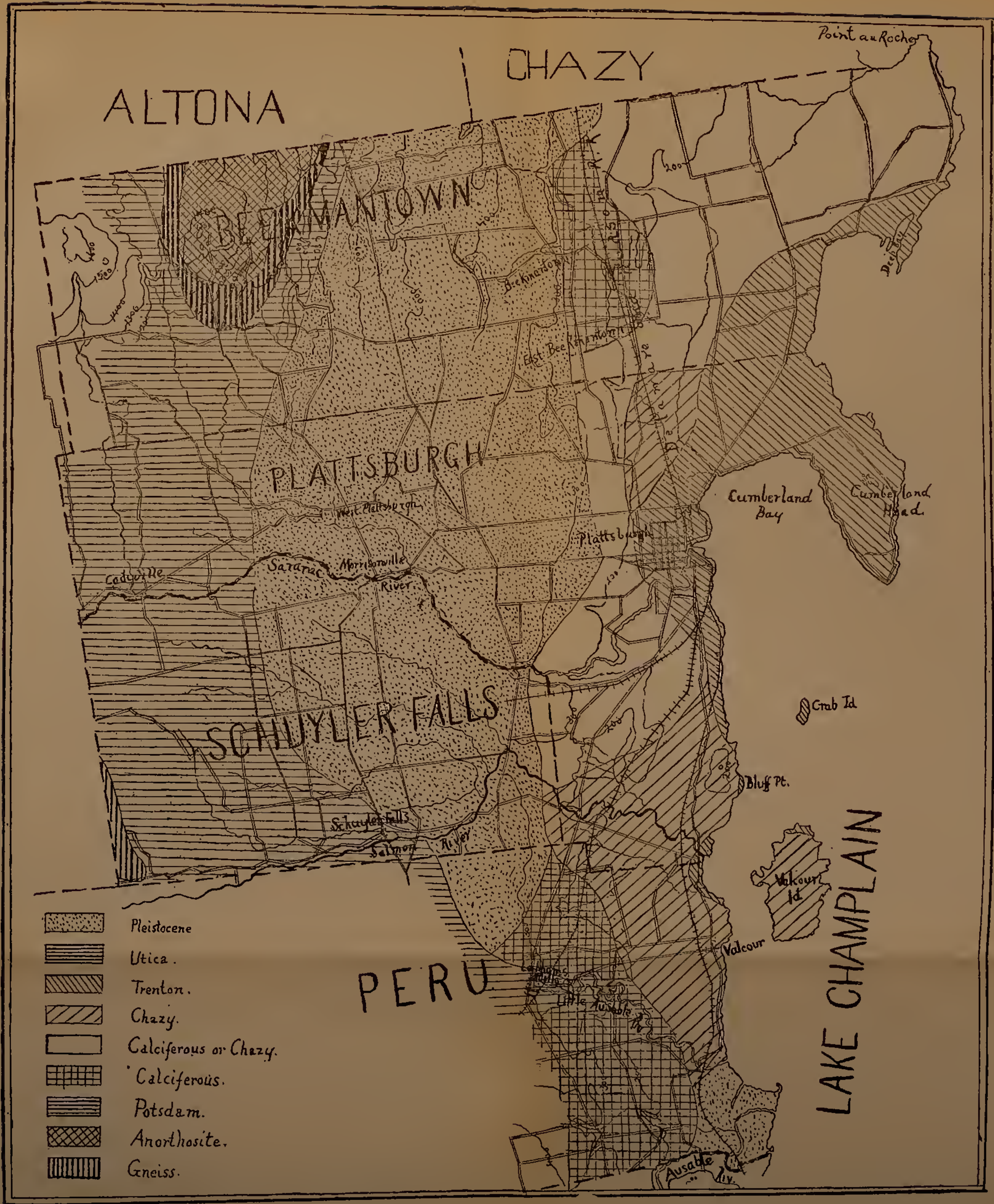
The pre-Cambrian rocks which, in Essex county to the south reach the shore of Lake Champlain, recede rapidly from the lake in Clinton county, and are confined to its southwest portion. Cambrian and Silurian rocks underlie all the county east and north in a broad belt which swings round the northeastern foothills of the Adirondacks. The altitude of this belt is low on the east, thence with a quite rapid rise as the pre-Cambrian area is approached. On the north the belt is higher and the rise more regular and even. In the tier of townships bordering on Lake Champlain, therefore, the altitude is slight, and only on their extreme western border are the edges of the first pre-Cambrian outliers met with. Embayments of Potsdam sandstone lie in the valleys between these outliers, precisely similar in occurrence to those bordering on the lake in Essex county. The townships comprised on the maps are Champlain, Chazy, Beekmantown, Plattsburgh and Schuyler Falls, with portions of Mooers, Altona and Peru. In Champlain, Chazy, Mooers and Altona outcrops are of sufficient frequency to permit the delineation of the surface boundaries between the various formations with great accuracy. In Beekmantown, Plattsburgh and Schuyler Falls, on the other hand, is a widespread area running down through their central portions in which all underlying rock is concealed from view by soil, drift and extensive plains of loose, barren sand, through which the roads wander at random, with much branching, and whose flora is in the main limited to huckleberries and stunted pines, just as is the case on the so-called Flat Rocks (Potsdam) in Altona township. This extensive area is underlaid almost wholly by Potsdam and Calciferous strata and efficiently conceals their contact and their respective extents from view. Areas of such character and extent as to make questionable what underlies them are indicated upon the map as such. The Potsdam boundary on the map of these townships shows the eastern limit of Potsdam outcrops. The formation itself certainly extends further east.

Pre-Cambrian rocks.—Though rocks of pre-Cambrian age were approached at several points, they were met with but twice. In the extreme southwestern portion of Schuyler Falls township the edge of a gneissic ridge of considerable dimensions appears, which lies mainly in Saranac township, west of Schuyler Falls, and is separated from a like gneissic outcrop in Dannemora, north of Saranac, by an embayment of Potsdam sandstone lying in the valley of the Saranac river. Where seen in Schuyler Falls, this rock differs from the ordinary acidic gneiss of the Adirondack region in its much more pronounced red color, extremely small content of bisilicates and very poor exhibit of gneissic structure.

In northwest Beekmantown an interesting gabbro (anorthosite) outlier is found occupying an area about three miles long and nearly two miles broad, the northern one-third lying in Altona township. On the east, south and west a narrow zone of gneiss intervenes between it and the Potsdam; on the north, however, the Potsdam lies directly on it. With the exception of a strip two miles in length on the northwest, the outlier was completely surveyed and found to be entirely surrounded by the Potsdam, so that it is practically certain that this is true of the whole, though the topography seems to indicate a greater width at the north end. This gabbro outlier presents many interesting features and merits careful study. Contacts between gabbro and gneiss, between gneiss and Potsdam and between gabbro and Potsdam are well shown. The area abounds in dikes, which will be mapped and studied at the earliest opportunity. The encircling gneiss is very variable in character, and passes in places into highly micaceous biotite schist. The major portion, however, is of the ordinary acidic gneiss. The gabbro in large part presents a distinct gneissic structure, the dark bisilicates being in parallel bands which, alternating with broader bands of white or greenish white labradorite, give the rock a striking appearance. Near Mr. Sanger's the rock more nearly approaches anorthosite than in any other exposure seen, and lacks the gneissic structure. Much of it exposed elsewhere is quite basic, and this is notably true as the periphery of the area is approached, where the rock is in general quite dark colored. The great abundance of garnet at nearly all exposures is a noteworthy characteristic and one of the many indications of the great alteration that the rock has undergone. The encircling Potsdam consists of arkose instead of sandstone, and consequently readily decays and disintegrates, so that its outcrops are not prominent. The single slide so far prepared shows that nearly one-half of the rock is made up of feldspathic grains, the feldspar being mainly orthoclase, a small amount of microcline being also present with an occasional grain of plagioclase.

Potsdam sandstone.—The Potsdam is much the most widespread formation in the area mapped, its width of outcrop north of the Adirondacks being very considerable. No data are yet at hand for determining its thickness, though measurements of several hundred feet, embodying only the known portion of the whole mass, have been made, as for instance that by Mr. Walcott at Ausable Chasm, on the south line of the county.* Moreover it lies unconformably on the earlier rocks, so that its thickness is a variable quantity. It presents great variation in coarseness, massiveness, color and degree of induration. Many layers disintegrate rapidly; others approach quartzite in appearance and durability; much of that forming the Flat Rocks in Altona is quite pebbly, but elsewhere in the district a coarse grit is the main phase; occasionally it becomes quite thin-bedded and

* Bull. U. S. Geol. Surv., No. 80, p. 344.



Scale ½ inch = 1 mile. 100 ft. contours

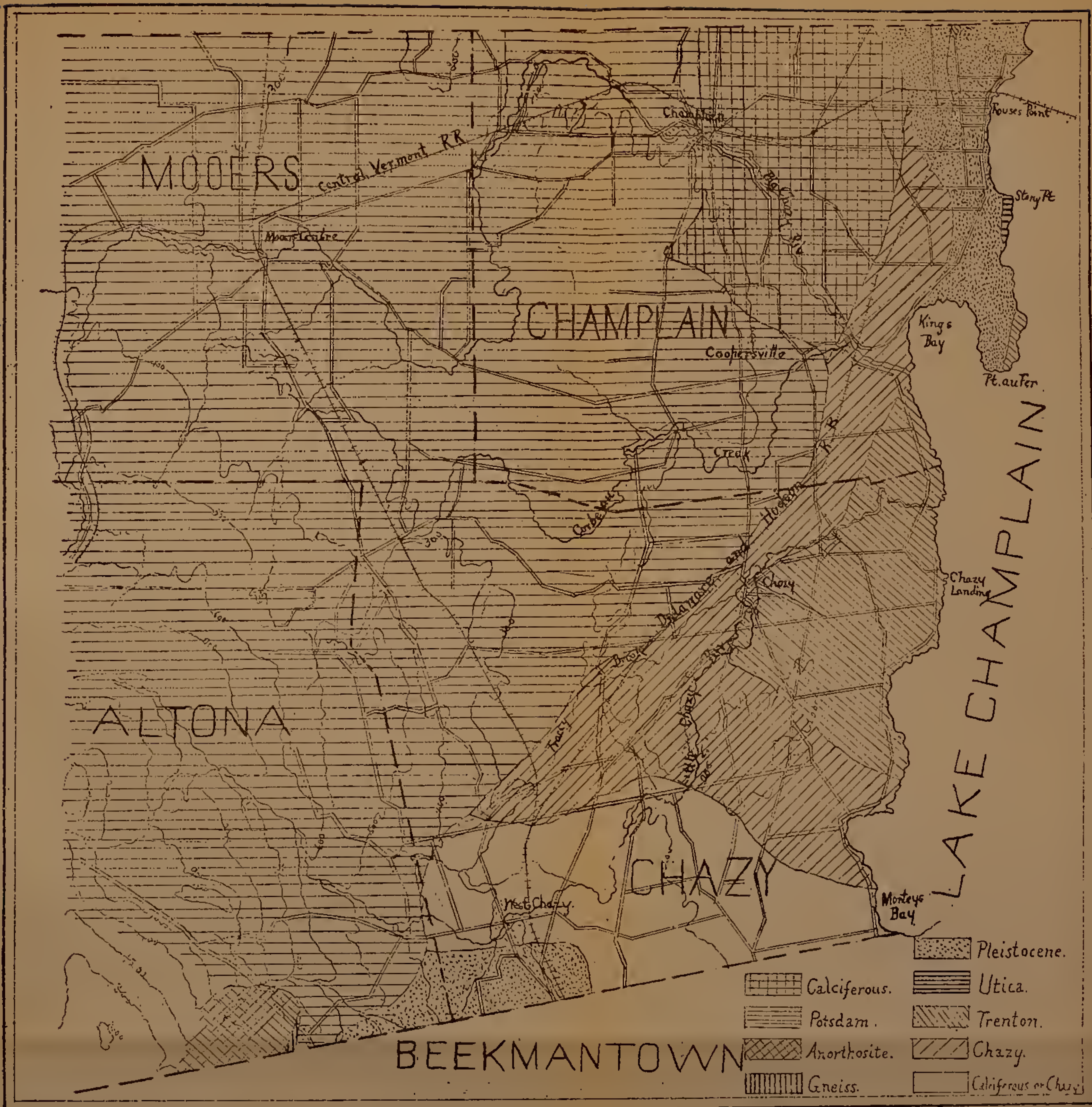
rarely shaly or slaty layers are met with; red and white are the prevailing colors, the red largely predominating with approach to areas of older rocks; but gray bands also occur, some with a greenish tint, yellow layers iron-stained in whole or in part are common, and finally glauconitic looking bands are also found. In Mooers, Champlain, Altona and Chazy the prevailing dip is about north twenty degrees east and quite gentle, seldom exceeding five degrees and commonly less. Further south the prevai ing direction is to the east, or south of east, but the dip is also gentle. Local discrepancies occur, as near Chazy village, where there is great variation in direction in a limited area, and at Lapham's Mills in Peru, where the dip is south fifty degrees west. These variations are in some cases certainly, and in others probably, due to local tilting accompanying faulting.

The Calciferous sandrock.—Rocks of Calciferous age occur exposed in considerable force in Champlain, Beekmantown and Peru townships, but in general the exposures are poor and scattered, and the order of succession and thickness of the various members has not been made out. The exposures in Champlain and Beekmantown give at least 400 feet in thickness, as a rough measurement, but this is surely only a fraction of the real thickness. The prevailing rocks are massive, gray or blue-gray, sandy dolomites, and dolomitic sandstones, very irregularly bedded, so that with poor exposures it is often a difficult matter to get a good determination of the dip. On exposed surfaces the calcareous material has been largely leached out, and in certain of the beds thick yellowish brown weathered sandy crusts are characteristic. In Champlain township, where its contact with the Potsdam is well exhibited, the typical Potsdam and typical Calciferous are separated from each other by a series of passage beds. These are dark-colored sandstones, sometimes pebbly, often quite coarse, which contain a small per cent of dolomitic matter. No such rocks have been found in the main body of the Potsdam, so their stratigraphic position seems clear, whether they be classed as Potsdam or Calciferous. Mr. Walcott has described similar passage beds at Chateaugay Chasm in Franklin county.* In this township an unknown thickness of the upper Calciferous and the basal portion of the succeeding Chazy limestone do not appear

*Bull. 80, U. S. Geol. Sur., p. 342-3.

in any exposures, and there is a certain amount of evidence to show that this non-appearance is due to a fault. In southern Champlain, and throughout most of Chazy township, the Calciferous does not appear and the Potsdam and Chazy limestone lie close together, though absolute contact is nowhere shown. This condition continues for a distance of nearly nine miles, from Coopersville in Champlain township to a point one and one-half miles north of West Chazy in the southwestern corner of Chazy township. At several points along this line, however, remnants of slightly calcareous, dark-colored sandstones are seen in direct contact with the Potsdam, though no contact with the Chazy has been observed. These are clearly continuous with the passage beds between the Potsdam and Calciferous in northern and central Champlain, and show that we have here the summit beds of the Potsdam. In Plattsburgh township the Calciferous is almost wholly covered by drift, and this is true to a considerable extent also in Beekmantown. In the latter a considerable thickness of Calciferous is exposed, but the upper and lower limits are nowhere shown, and it seems certain that only a comparatively small part of the entire thickness of the formation is shown. It would also seem that it is higher than the Calciferous in Champlain township. In Peru township the Calciferous again appears in considerable force, but no data for determining its thickness were disclosed by last season's work.

Commencing in southern Chazy, and extending thence in a belt through Beekmantown and Plattsburgh township, a series of unfossiliferous, somewhat sandy dolomites is exposed, overlying the undoubted Calciferous, carrying *Ophileta*, in Beekmantown, or at least lying east of it. This resembles it lithologically, and would be unhesitatingly classed as Calciferous were it not that certain features of the stratigraphy seem to indicate a Chazy age. The typical fossiliferous rocks of the three divisions of the Chazy are nowhere exposed in Beekmantown, with a single possible exception, though widely exposed in Chazy on the north and in Plattsburgh on the south. As the Chazy rocks are followed south through Chazy township they disappear entirely and in their stead these unfossiliferous beds appear, where any exposures are found. They continue south through Beekmantown to the Plattsburgh line, where they apparently are



Scale ½ inch = 1 mile. 100 ft. contours.

directly beneath the Chazy. Where nearest together the dip of the former is five degrees to north fifty degrees east, and of the latter ten degrees to north sixty degrees east, and the Chazy beds exposed are by no means the basal beds, so it is possible there is some dislocation here. These beds have been mapped separately as either Chazy or Calciferous, pending further investigation of their position and relationships. In the central portion of Chazy nearly the entire width of the township is occupied by clearly marked Chazy beds. A short distance to the south they run out except at the extreme east, and their place is taken by these unfossiliferous beds which are the only ones that outcrop in Beekmantown between the Calciferous and the Trenton along the lake shore, outcrops of the two series lying quite close to each other.

Chazy limestone.—The Chazy limestone is excellently and nearly completely shown in Chazy township, and on Valcour Island, and less completely at Bluff Point. Careful detailed sections at Chazy village and on Valcour Island, have been published by Messrs. Brainerd and Seely, and were of great assistance to me.* They have subdivided the formation into lower, middle and upper Chazy, recognizable readily by their fossils, and in general by their lithological character, and with fossils so numerous in beds not widely apart vertically, that with fair exposures their recognition is a simple matter.

Outcrops of the Chazy limestone in Champlain township are of infrequent occurrence, but sufficiently scattered to permit fairly accurate mapping. These outcrops are all of the middle Chazy (the *Maclurea* beds), and none of the upper and lower divisions could be found. If the *Maclurea* beds in Smith's quarry, southwest of Rouse's Point, were prolonged along the strike they would almost come in contact with the easternmost exposure of Calciferous on the Central Vermont railroad west of Rouse's Point and one mile north of Smith's quarry, so that here apparently the lower division of the Chazy and a considerable portion of the upper Calciferous are lacking, and this on the prolongation of the line along which, further southwest, the Potsdam and Chazy are brought together. In Chazy township the Chazy limestone is magnificently shown. In the

*Am. Geol., Vol. II, pp. 323-30; Bull. Geol. Soc. Am., Vol. II, pp. 292-300.

small area just south of Chazy village mapped by Brainerd and Seely, nearly the entire series is shown, the higher beds outcropping a mile east of the lowest, and capped by the Black River and Trenton which continue on thence to the lake.* But less than three miles south of Chazy village the easternmost Chazy outcrops are four miles distant from the most western, and the eastern outcrops are not of the upper Chazy but of the *Maclurea* beds. The dip is somewhat less than at the village, but by no means sufficiently so to account for the greatly increased width of outcrop; narrow definite horizons are found repeated in going from east to west. A barren interval in which no outcrops occur appears in the center of the area, and rapidly widens toward the southwest, while in the southern part of the township outcrops of the unfossiliferous dolomite of doubtful age begin to appear. On the Chazy–Beekmantown line, and for two miles north of it, no exposures occur in the entire width of Chazy township, except these few outcrops in the center, and others near West Chazy, which are believed to be Calciferous sandstone, but for the present are classed provisionally with these beds. As has already been stated, no Chazy fossils have been found in Beekmantown, the only exposures being of these unfossiliferous beds, whose outcrops run close to the Trenton exposures along the lake, indicating that much or all of the Chazy is lacking here. Just across the line in Plattsburgh township, however, the Chazy reappears and is largely quarried along the road from East Beekmantown to Plattsburgh, but only a small portion of the entire thickness is shown. Further south, at Bluff Point, is an excellent section, about 350 feet thick, comprising a large part of the lower and middle divisions. At the large pulp mill, at the rapids in the Saranac river, three miles southwest of Plattsburgh, fifty feet of alternating limestone and slaty layers, with sandy bands at the bottom, are well shown, and are believed to represent the basal beds of the Chazy on Valcour Island, as described by Messrs. Brainerd and Seely.* Thence westward the township furnishes no outcrops till the Potsdam ledges are reached.

In northeastern Peru a portion of the Chazy limestone outcrops near the lake shore, disclosing the upper beds of the lower division, and the basal *Maclurea* beds. Exposures further south are shut

* Am. Geol., Vol. II, p. 326.

† Bull. Geol. Soc. Am., Vol. II, pp. 291–5.

off by the sweep of the earlier formations round to the east, bringing the Calciferous to the lake shore in southern Peru, followed in turn by the Potsdam and gneiss in Essex county.

Trenton limestone.—Exposures of the Trenton beds are quite frequent along the lake shore, or close to it, but are difficult of subdivision because of the usual meagreness of the exposures and the similarity of the different beds. The main phase presented is a black limestone with a pronounced slaty structure. The Black River limestone at the base is more massive than most of the Trenton, and is seen directly capping the Chazy at a number of localities, notably Chazy township. Much of the Trenton is quite fossiliferous, but near the base is a series of beds of very slaty character, in which fossils are for the most part absent.

In Champlain township but a single exposure of beds referable to the Trenton is found, a series of black and dark blue slates and slaty limestones, weathering light colored, much jointed, the seams generally filled with calcite, whose outcrop extends along the lake for a quarter of a mile north of Point au Fer. Search for fossils was unrewarded, and as the exposure is an isolated one the reference to the Trenton rests on lithological character alone. The apparent dip is seventy degrees to the northwest, anomalous for the region, and unexplained till similar beds on Cumberland Head having the same apparently high dip were examined. Careful examination of the excellent exposures along the east shore of Cumberland bay showed the true dip to be a gentle one to the northeast, and that the apparent high dip was caused by a series of joint or shear planes, commonly only an inch or two apart, which dip to the southeast at angles varying from thirty to sixty degrees. To these planes is due the slaty aspect of the rock, and they closely mimic bedding planes. A series of nearly vertical joints is also present. The true dip may be made out where locally the shear planes are less pronounced, or where there are variations in the color of the different layers across which the shear planes cut. Locally some slipping has taken place along some of these planes, as is shown by the bent edges of the layers adjoining the plane, and their non-correspondence on the opposite sides, as well as by the occasional appearance of slickensides. All the rock is much shattered, and the cracks are, for the most part, filled by seams of calcite, varying from the breadth of a hair up to two or three inches. This peculiar shearing is more prominent also in certain layers than in others, and some are nearly free from it. These slaty limestones are also unfossiliferous, and, it is thought, furnish a possible explanation of the dip at Point au Fer, for the demonstration of which the Point must be revisited. In Chazy township the Trenton belt possesses considerable width, presenting numerous, though very poor outcrops, which in general are abundantly fossiliferous. In the river-bed near Chazy village the lower beds occur, conformably overlying the Black River and Chazy limestones, with a dip of twenty-five degrees to north, sixty degrees east. One mile to the northeast the Trenton is again exposed in the river-bed at a mill, and here dips ten degrees south, fifty degrees east, the *Maclurea* beds of the Chazy, which outcrop one-quarter of a mile to the northwest, having the same dip. Between these points and the lake, however, all the dips are to the northwest, though exposures are too poor in the main to furnish reliable dips. This Trenton belt east of Chazy village is three miles wide, then cut off by the lake, but passing south it rapidly narrows, and the Chazy limestone reaches the shore at Montey's bay.

In Beekmantown, rocks referred to the Trenton are found in the southern part of the township in a belt one and one-half miles wide, back from the lake shore, the black, slaty limestones outcropping in a series of short, sharp parallel ridges, with a rather steep dip to the south of east, and continuing on into Plattsburgh township, sparingly fossiliferous, but sufficiently so to demonstrate their age. North of these Trenton beds are frequent exposures along the lake shore, of rocks somewhat resembling them, which furnished practically no fossils, and which, for the present, must be classed as of uncertain age. They consist of thin beds of dark blue or nearly black limestone, with some slaty beds, occasional blue-gray beds, and some quite sandy, light-colored beds. They are, as a whole, more massive than the Trenton beds south of them and differ in dip, this being north of east instead of south of east, and veering gradually to the north as they are followed north along the lake. At the extreme end of Point au Roche the dip is north thirty degrees west; eighty rods to the west, on the shore of Montey's bay north five degrees east; south of Point au Roche it rapidly swings to the north. The geological structure on Isle la Motte, one mile east of Chazy township, whose length from north to south nearly equals the township's length, seems to indicate a Calciferous age for these Beekmantown beds. On Isle la Motte the upper Calciferous is exposed at the southern end of the island, followed, going north, by the entire Chazy, and this in turn by the Black River and a portion of the Trenton, the whole dipping to the north. Apparently coinciding with this distribution we have the Chazy limestone in Chazy township sweeping round to the lake shore and cutting out the Trenton. If the coincidence is real, and not merely apparent, we should expect to find the Calciferous following the Chazy to the south in a similar sweep, in other words, occupying the stratigraphic position in which the debatable beds are found in southern Chazy and North Beekmantown. These beds are also in large part like the Calciferous lithologically, but this is not true of that portion of them under discussion, which more nearly resemble the Trenton. In the top layer of these beds on Point au Roche, the layer being markedly pyritiferous, a small gastropod and a *Leperdita*-like form are very abundant, and may prove sufficient to positively determine the age.* Rocks similar to those in South Beekmantown and carrying the same Trenton fossils (*Asaphus gigas* is the most common form) are exposed all over Cumberland Head in Plattsburgh township, their peculiar secondary cleavage having already been described. Similar beds, with the same peculiarities, appear on the lake shore just south of the city of Plattsburgh, forming a considerable cliff. On the shore at Bluff Point the Trenton is again exposed in a cliff some fifty feet in height. Here it is lighter colored and more massive than the black slaty beds, carries a more abundant fauna, and seems to represent a somewhat higher horizon. A large *Strophomena* is the most abundant and conspicuous form, numerous individuals showing on the face of the cliff. On ascending the cliff and thence following up the slope to the

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*For the geology of Isle la Motte see Brainerd and Seely in Bull. Geol. Soc. Am., vol. II, p. 297.

summit of the Point, the Chazy limestone appears coming close to the lake, with a dip which would carry it against the Trenton, if prolonged to the lake, though the dip of both is the same, five degrees south, forty degrees east. On Crab Island, one and one-half miles northeast of Bluff Point, the Trenton is beautifully shown in part, dipping ten degrees to the north, somewhat more massive than on the mainland, but still quite slaty, apparently higher up in the group, and affording beautifully preserved fossils in abundance, many forms occurring here which were not seen in the slaty beds on the shore, among others *Bellerophon bilobatus*, a *Nucula*, two species of *Tellinomya*, and two species of *Lingula*. In northeast Peru black slaty limestone with occasional fossils is exposed on the lake shore, but is soon cut out by the appearance of the Chazy on the shore to the south, and is the most southerly exposure of Trenton limestone in the county.

Hudson River group.—But one exposure of rock later than the Trenton limestone in age occurs in the county. At Stony Point, one mile south of Rouse's Point, running thence for about half a mile along the shore south of the breakwater, is an outcrop of black calcareous slate, or slaty limestone, cut up into small blocks by vertical joints which are filled with calcite and resembling much of the Trenton, though more slaty. In all about twenty feet are exposed, and throughout fossils are quite abundant. The fauna is that of the Utica slate, *Triarthrus Beckii* and *Graptolithus pristis* being the only common forms, associated with them being occasional specimens of *Endoceras proteiforme*, and rarely some species of graptolites. The dip is ten degrees to the northwest.

Structural characteristics.—The prevailing dips of the region are gentle, commonly ranging from five to ten degrees. Locally they sometimes become quite steep. They range ordinarily in direction from north to northeast, east and somewhat south of east, the former being more common north of the Adirondacks, and the latter east of them, or in other words, the dip is in general away from the mountains. Dips to the west are exceptional and local and can generally be shown to be accompanied by a fault. Folds are practically absent, though a slight amount of local folding has occurred here again in the vicinity of faults. Faults, on the other hand, abound. The largest and most conspicuous of them are meridional. with the downthrow always on the east. In addition, where outcrops are sufficiently numerous, cross faults can also be shown to occur, though of much less magnitude than the meridional ones. Sometimes the faulting has involved little or no change in dip, at other times a marked discrepancy exists in the dip on the two sides. Some of the faults can already be indicated, more detailed work will undoubtedly disclose others; still others there must be, evidence of which is securely hidden from view by widespread concealment of the rocks.

In Champlain township the Utica slate at Stony Point lies less than a mile east of an outcrop of Chazy limestone, exposed along the road running south from Rouse's Point, dipping six degrees to north, fifty degrees east, whereas the Utica beds dip ten degrees to the northwest. A marshy tract intervenes in which no exposures occur, but nearly the entire thickness of the Trenton must be faulted out. A like fault, by which the Utica slate is brought into juxtaposition with the Chazy, is stated by Messrs. Brainerd and Seely to occur on the east side of Isle la Motte.* On which side of this fault the Trenton beds at Point au Fer lie is uncertain.

Messrs. Brainerd and Seely have mapped in detail a small district in Chazy township just south of Chazy village.† Two cross faults of comparatively small throw are shown on the map, and the presence of two other faults in the vicinity is indicated. At least one of these locations proves to be of considerable magnitude and extent. From the Chazy-Champlain line for a distance of more than five miles to the southwest through Chazy township the railroad follows rather closely the edge of the Potsdam outcrop, exposing it frequently in cuts. Throughout this distance the Calciferous is absent, though the passage beds are found overlying the Potsdam, and Chazy outcrops are frequent, lying close to the Potsdam, often at a lower level and with a different and generally much steeper dip. The area of greatest dislocation is at Chazy village. A railroad cut through Black River limestone, which is only a few yards east of a ridge of Potsdam, occurs one mile northeast of the village. Nearer

* Am. Geo., vol. II, p. 327. † Am. Geo., vol. II, p. 326.

the village other Black River outcrops lie nearly as close to the Potsdam. In the vicinity of the village the greatest and most rapid variations in the strike and dip of the limestones occur. On the Champlain-Chazy line the *Rhynchonella plena* beds of the upper Chazy lie close to the Potsdam, with a strike which would bring them together a short distance away. Passing north into Champlain township no outcrops between the Potsdam and the lake appear till Coopersville is reached. The Potsdam exposed in Corbeau creek, west of Coopersville, with a dip of five degrees to the north, lies only three-quarters of a mile west of an outcrop of the *Maclurea* beds, dipping five degrees to the east, much too narrow an interval to contain the lower Chazy beds and the entire Calciferous. North of Coopersville the Potsdam line of outcrop swings to the west and the Calciferous begins to appear. At first only the passage beds are seen, but further north a considerable thickness of the lower Calciferous beds occur, and it has already been shown that along this fault line in Champlain township the lower division of the Chazy and an unknown amount of the upper Calciferous are lacking. In western Chazy the lower division of the Chazy limestone lies close to the Potsdam. South of these Chazy outcrops the unclassed dolomites, probably Calciferous, appear at West Chazy, and beyond this point southward any further tracing of this dislocation is made impossible by the total lack of exposures. There is clearly a fault along this line, whose position on the map is indicated by the western edge of the Chazy outcrop throughout Chazy and Champlain townships. The greatest disturbance and maximum throw are at Chazy village, decreasing thence north and south.*

In Chazy township are further evidences of dislocation. A little over a mile south of Chazy village the line of Chazy-Trenton contact swings to the east, the Chazy-Potsdam contact continuing to bear to the southwest. Three miles south of Chazy village, as a result of this divergence, Chazy rocks outcrop throughout a belt four miles in breadth, whereas at Chazy village, with only slightly increased dip, the entire formation outcrops within a breadth of one mile. Moreover, passing across

* Conf. Brainerd and Seely, Am. Geol., vol. II, p. 327; Bull. Am. Mus. Nat. Hist., vol. III, d. 12; C. D. Walcott, Bull. U. S. Geol. Surv. No. 30, p. 22.

the strike easily identifiable beds, such as the stratum with red spots, are found repeated, sometimes more than once. Still further south the beds on the east are separated from those on the west by a region not prolific in outcrops, but occupied at least in part by the unfossiliferous dolomites. Still further south the *Orthis* beds of the lower Chazy on the west disappear, and in their stead we find the Calciferous (?) at West Chazy. On the east the beds swing round to the lake, shutting out the Trenton, and are succeeded to the south by the questionable beds along the lake shore in Beekmantown. If these be Trenton, there must be a fault between them and the Chazy to the north, which runs out under the lake; otherwise the geology of Isle la Motte can not be explained. If they are lower than the Trenton there must be a fault between them and the Trenton beds further south in Beekmantown. There must be a considerable fault in Chazy township, with perhaps minor ones to account for the width of the Chazy belt, the repetition of portions of it and its final separation into two parts by the tongue of Calciferous (?). There is a probable fault in the Trenton east of Chazy village, as shown by the abrupt change from northeast to northwest dip, already mentioned. The total absence of the Chazy limestone from Beekmantown township, while the Calciferous (?) comes close to the Trenton, indicates a fault of considerable magnitude, the same continuing on into Plattsburgh, with the introduction, however, of a wedge comprising a portion of the Chazy. There is a fault at Bluff Point, where Trenton limestone, not representing the basal portion of that formation, abuts against the *Maclurea* beds of the Chazy. There are hints of other faults, as yet too vague to be mentioned. Those here mentioned are sufficient to indicate the structural features of the region. I hope in the near future is to make these statements more precise and to map the formations in detail.

Respectfully yours,

H. P. CUSHING.

Adelbert College of Western Reserve University,
February 8, 1894.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

REPORT

ON A

Preliminary Examination of the General and Economic Geology of Four Townships in St. Lawrence and Jefferson Counties, N. Y.

JAMES HALL, STATE GEOLOGIST. | C. H. SMYTH, JR., ASSISTANT.

1893.


COUVERNEUR
Calciferous
Potsdam
Limestone
Gneiss

REPORT

ON A

Preliminary Examination of the General and Economic Geology of Four Townships in St. Lawrence and Jefferson Counties, New York.

BY C. H. SMYTH, JR.

Prof. JAMES HALL, *State Geologist:*

SIR.—The genetic and structural problems presented by the crystalline rocks of northern New York are of such a nature that their solution demands extended and careful investigation. The present paper is submitted not as a final contribution to the geology of the region, embodying the result of thorough study, but, rather, as a report of progress, giving some idea of the character of the problems to be solved and the efforts made toward that end.

The area examined contains about 225 square miles and includes the towns of Gouverneur, Fowler and the southern part of Rossie in St. Lawrence county, and Antwerp in Jefferson county. This area is occupied in the main by rocks belonging to four lithologic groups, viz., gneiss, granite, crystalline limestone and sandstone or quartzite. These lithologic groups are used as a basis for the accompanying map, no other mode of classification being as yet available. But these distinctions are not without their time value, as the sandstone is clearly the most recent rock, the granite next, while a portion of the gneiss is probably the oldest, underlying all the others. These rocks, as they occur in a small portion of the area examined, have been described by the writer*

* C. H. Smyth, Jr.; A Geological Reconnoissance in the vicinity of Gouverneur, N. Y., N. Y Acad. Sci., XIII, pp. 97-108, also Petrography of the Gneisses of Gouverneur, N. Y., ibid., pp. 203-217.

with some detail and only the more important points need be summarized here. A greater amount of variation is naturally found in the rocks, as the examination extends over a wider area. This is particularly true of the gneiss, of which several varieties occur, ranging from a medium-grained, roughly-banded, granitic rock, to a fine, thinly laminated variety on the one hand, and to a coarse "augen-gneiss" on the other.

As a rule the gneiss consists of quartz, orthoclase, plagioclase (these two commonly as microperthite), biotite and hornblende, with the usual minor constituents. The finely laminated varieties, which are usually in close proximity to, or interbedded with limestone, often contain sillimanite and garnet.

The granite also shows much variation and sometimes so closely resembles the gneiss that their separation becomes a matter of much difficulty. In one instance a large area of granite was regarded as gneiss, until an irruptive contact with the limestone was found. This explains the apparent absence of granite in the gneiss areas, as shown on the map. While granite undoubtedly often occurs in the gneiss, it could not be distinguished without closer study than was possible in the time allotted to field work.

The normal granite is a medium-grained aggregate of quartz, orthoclase, plagioclase and biotite. The biotite is often absent and the granite, therefore, of a very acid variety, which is commonly coarse grained. On the other hand, basic segregations also occur, in which biotite is replaced by abundant hornblende, and orthoclase by plagioclase, the rock passing into diorite. Such basic masses are usually not extensive, and pass gradually into the ordinary granite. But just south of the Oswegatchie river, near the Rossie-Gouverneur town line, there is a large area of very dark and coarse diorite which shows no connection with any granite. On account of its size and independent occurrence it is indicated on the map by a distinct pattern, although, without doubt, it belongs to the series of granite intrusions. These intrusions cut the limestone, but not the sandstone, and are, therefore, of pre-Potsdam age.

The limestone is highly crystalline and, as a rule, quite coarse. It varies in color from white to gray, and on weathered surfaces is nearly black. Mica and graphite are commonly disseminated through it in scales, and many other minerals occur more or less segregated. Serpentinous varieties are not uncommon, the serpentine being secondary after amphibole, pyroxene, etc. The limestone often contains black hornblendic and pyroxenic bands, which are twisted into a great variety of fantastic forms. Knots and bumps of various silicates are also common, particularly in the vicinity of granite. Sometimes the limestone becomes tremolitic and passes into a tremolite schist, an important fact from an economic standpoint, as the tremolite schist seems to be the source of the talc now mined on a large scale.

The sandstone is usually rather fine-grained and indurated by secondary silica, forming a compact quartzite. Occasionally coarse conglomerate varieties are seen. The color varies from white to red, often with complex mottling and striping.

A brief examination suffices to show that the sandstone is much younger than the other rocks of the region and lies unconformably upon them. It is of Potsdam age and its relation to the older rocks has been recognized by all geologists who have studied the region, excepting Brooks,* who regarded it as conformable with the limestone.

With this unconformity established, the chief structural problem of the region lies in the relation of the limestone to the gneiss. In the hope of shedding some light upon this problem a limited area was examined with much care, an effort being made to collect as many facts as possible in regard to dips and strikes, contacts, etc. The highly unsatisfactory results thus obtained have been stated in the papers above cited. The massive character of the limestone, the difficulty of establishing definite horizons to be traced from point to point, and the rarity of contacts combined to render all efforts in this direction nearly futile. It was, therefore, determined to prepare a map showing the areal relations of the rocks over a more extended surface, in the hope that the distribution, combined with such other data as might be collected, would give the key to the structure of the region. The accompanying map represents what has thus far been done in this direction. For the field work only very inaccurate township maps, which required much readjustment in order to be fitted together, were available. With such a basis in consideration of the particular object in view, it

* T. B. Brooks, Amer. Jour. Sci. (3), IV, p. 22.

was deemed inadvisable to attempt any very close work. As it now stands the map gives, with fair accuracy, the distribution of gneiss and limestone, though there are several doubtful points along the northern edge. The more important areas of sandstone and granite appear, their precise extent and outline not often being shown, while doubtless a large number of minor patches are wholly omitted. In fact, the areas of sandstone and granite are so irregular in distribution, outline and extent that every square rod of the region would have to be traversed to ensure their accurate representation.

In the course of the mapping it was clearly ascertained that a portion of the gneiss is interbedded with the limestone, and in every instance observed this gneiss is of the well laminated variety. Similar laminated gneiss is usually seen in passing from the limestone to the large gneiss areas. This is well shown near the Old Sterling mine in Antwerp, at Keene's Station and in Hailesboro, two miles south of Gouverneur. The gneiss as seen on its northern edge is finely laminated, often crumpled, and contains garnet or sillimanite or both. Going southward toward the center of the gneiss area, the rock becomes more massive and coarse grained, in places decidedly granitic, and at some points shows coarse porphyritic phases and "augen-gneiss." As before said, this is the common character of the passage from limestone to gneiss, but there are many localities where the laminated gneiss is wholly wanting, the limestone being in contact with the massive gneiss.

From their character and position it would seem that all of the laminated gneisses must be regarded as belonging with the limestone, as members of a series of uncertain, but very considerable thickness, unconformable beneath the Potsdam. It will be convenient for reference and, according to the writer's opinion, in the interest of exact terminology, to give to this series a local name rather than to employ an assumed correllation with other regions, which is not yet established. As the Oswegatchie river flows many miles through these rocks the name *Oswegatchie series* is suggested as particularly appropriate.

As to the origin of the rocks there seems to be no reason for considering them other than true sediments, though extreme metamorphism has removed all trace of clastic structure. At least, they have so much the appearance of metamorphosed sediments that the burden of proof must rest with those who would maintain for them a different origin.

While the summit of the Oswegatchie series is clearly defined by a great unconformity, the position of its base is, as yet, a matter of doubt. The reasons for this will become plain upon the consideration of the distribution and character of the rocks, and their structural relations. The areal distribution of gneiss and limestone shown on the map and the steep dips common in the rocks suggest the possibility of the existence of a series of folds with crests and troughs pitching to the northeast. As nearly all the recorded dips are northerly it would seem that there may be an overturning of the folds, giving the axes (the axial planes which bisect the folds)* an inclination to the northwest. On this point, however, there is an insufficiency of data; although, it may be added, the character of the minor distortions so commonly seen in the black schists is in harmony with this view. This hypothesis of folding affords the most satisfactory explanation of the peculiar distribution of the rocks and other facts now at hand; and while areal relations supply a very unsatisfactory basis for structural conclusions in the present instance, more reliable data failing us, a provisional acceptance of such conclusions, until they may be established or discredited by further investigation, will aid, rather than retard, the inquiry.

Assuming for the present this interpretation of the structure, the question remains: Does all of the gneiss which spreads over so much of the region belong with the limestone in the Oswegatchie series; or is part of it, and if so, how much, older and unconformable below that series? Until this question is answered it is, of course, impossible to prepare a map of the region which shall show the rocks grouped strictly upon a time basis. The difficulties in settling the matter result from the completeness of metamorphism. The gradual transition from the laminated gneiss into the massive gneiss, and the general agreement in strike and dip point strongly to continuity of deposition. But, on the other hand, such transition and agreement in structure

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*Margerie et Heim, Les dislocations de l'écorce terrestre; W. H. Hobbs, Journal of Geology, I, p. 733.

might well result from folding with intense metamorphism, which would produce parallelism in structure and give a transitional character to the rocks along the contact of the two formations. Instances of such action are well known in the Appalachian region and elsewhere. Furthermore, the granitic and augen-gneisses differ so greatly from the laminated varieties associated with the limestone that they suggest an entirely different origin, and, while some of them may be accounted for as later intrusions in the surrounding rock, this explanation must be employed with caution, as the establishment of the intrusive character is often difficult or even impossible. Still, if the explanation of structure given above be correct, these massive gneisses represent the lowest rocks of the series, and their character might have been influenced by the depth to which they were buried and by the intrusion of much igneous material.

Thus, the base of this Oswegatchie series is as yet undetermined, and its position is one of the important problems to be solved. With the evidence at hand a final decision of these points is out of the question.

The general similarity of the Oswegatchie series to the Grenville series of Canada is very marked, suggesting, as observed by Van Hise,* a possible equivalency. The same difficulty exists in both series, in determining their lower limits and their relation to the underlying rocks. For the Oswegatchie series, it is hoped that the problem may be solved by extending the mapping over a larger area and with greater detail; by accumulating data for the construction of sections across the series; and by ascertaining the true nature and origin of rocks whose affinities are at present doubtful. Nothing can so greatly aid the prosecution of this work as good topographical maps, and the sooner these are available the sooner the task will be accomplished.

ECONOMIC GEOLOGY.

Iron Ore.

This portion of the State has long been known as a source of iron ore, the Rossie and Antwerp red hematites having been mined for many years in some quantity. In earlier days these ores were smelted on the ground in charcoal furnaces, but later

*C. R. Van Hise, Bull. 86, U. S. G. S., p. 508.

were sent to various iron centers for mixture with more refractory ores. At the present time the depression in the iron business and great development of richer ores combine to render the working of these mines unprofitable.

The question of the origin of these ores has never been settled, nor, in fact, discussed at any length since the early days of the New York Geological Survey. At that time Emmons* gave with some detail his reasons for regarding the ores, together with the associated so-called serpentine, as irruptive. Vanuxem,† who studied more particularly the ores in Lewis county, considered them rather superficial concentrations, lying between the crystalline rocks and the Potsdam sandstone and as closely connected with the latter as with the former. At a much later date Brooks‡ examined the Rossie mines and concluded that they showed a continuous series of sedimentary deposits, including sandstone, ore, magnesian rock (serpentine of Emmons), and crystalline limestone, together with some granite. Still later Smock§ states that there are probably two classes of ore deposits, the original sediments and secondary concentrations, but he does not give the facts upon which his inferences are based. Kimball‖ states that the ores are the result of replacement of limestone but gives no description of their mode of occurrence other than to say that he examined particularly a mass of specular ore in Pierpont, which was in crystalline limestone of Calciferous age. This determination of the age of the crystalline limestone is doubtless incorrect.

It is thus evident that there has been much diversity of opinion in regard to the origin of the ores, among those who have studied them. While the writer scarcely feels prepared to draw final conclusions from the work thus far done by him on these deposits, it may be worth while to state some of the facts observed, together with what seems at least a reasonable explanation of them.

That the problem is not simple is evident from the variety of opinions expressed in regard to it. The great difficulty lies in

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* E. Emmons, Geology of New York, 2d District, p. 97.

† L. Vanuxem, Geology of New York, 3d District, p. 267.

‡ T. B. Brooks, Am. Jour. Sci. (3), IV, p. 22.

§ J. C. Smock, Bull. N. Y. State Museum, No. 7, p. 10.

‖ J. P. Kimball, Genesis of iron ores by isomorphous and pseudomorphous replacement of limestone, etc., Amer. Geol., VIII, p. 368.

the scarcity of data available at the mines. The outcrops are generally very unsatisfactory, and the rocks highly altered, and often of doubtful character. At the time of the writer's visit the difficulties were increased by the fact that all the mines were shut down and most of them flooded. Moreover, it was found impossible to procure any drawings or details of the workings.

At only one mine, the Old Sterling, were at all satisfactory data collected, and even here much was to be desired. It follows that the conclusions reached are largely based upon the facts as shown at this locality and much is inferred as regards other mines. But, while there are many local variations, there is such a strong general resemblance in the deposits of the various mines that it seems almost certain that they must have had a common origin.

Upon examination and comparison of the important mines of the region it becomes apparent that any satisfactory explanation of the origin of the deposits must account for several facts in regard to the mode of occurrence of the ores and associated rocks, which seem to be intimately connected and constant features. Of these facts the more important are the presence of the Potsdam sandstone, resting upon and grading into the ore, the linear distribution of the deposits along the strike, the irregularity in the form of the ore bodies and variation in the character of the ore, the common presence of granite intrusions in the ore, a remarkable alteration of this granite, together with other indications of much chemical action.

The presence of the sandstone forming the cap and grading down into the ore was one of the first facts noted in studying the deposits. So constant did this seem to be that it was thought there must be some genetic connection between the rocks. As it was evident that the ore lay in, not on, the crystalline rocks, it could not be regarded as contemporaneous with the sandstone. The first explanation of association that offered itself was that an originally ferruginous sandstone was deposited upon limestone, that underground waters containing carbon dioxide, organic acids, etc., passing through the sandstone dissolved the iron and carried it down to the limestone, where the iron replaced the lime and by subsequent changes became hematite. While this hypothesis explains the association of ore and sandstone and the common transition between them, its details are obscure and it leaves many things unexplained, particularly the presence of the altered granite and the distribution of the ore bodies. It, therefore, seems necessary to abandon the hypothesis as applied to the ores in general, though it may account for some small local deposits.

The distribution of the ore suggests another possible mode of origin. The most important group of mines forms a belt beginning a short distance northeast of Antwerp village and extending to the line of Gouverneur township, in a direction parallel to the strike. Moreover, the laminated gneiss lies a short distance south of all the mines. This is just the distribution that would be looked for in a series of stratified deposits, and points quite strongly to the supposition that the ores are original sediments. The difficulty of procuring accurate sections prevents an absolute determination as to whether or not the ore bodies do occupy a definite horizon in the series, but so far as the evidence goes, it indicates that they approximate such a constant position, though varying slightly from it. In this direction, then, the question is not yet settled, though the indications are against original deposition. Further indications tending to weaken this explanation are afforded by the ore bodies themselves, in their irregular shape and the abundant signs of secondary accumulation, such as stalactitic, crustified and cavernous deposits. It might be urged that these facts could be completely explained by the action of various agents subsequent to the deposition of the ore, but such an explanation seems insufficient It would rest upon the facts that, if it is an original sediment, the ore has been subjected to intense dynamo-metamorphism along with the Oswegatchie rocks, and has, further, often been penetrated by intrusions of granite. Here are afforded perhaps sufficient causes for some of the peculiarities of occurrence stated above, but a new question is raised: Would not the ore, if subjected to these two kinds of metamorphism, have a very different character from that which it actually possesses? While opinions may differ on this point, it seems to the writer very probable that an ore thus acted upon would not be a variable, often earthy and cavernous, red hematite, but rather a uniform specular hematite, or a magnetite.

Certainly these are the forms of ore produced by metamorphism, and in the present instance the metamorphism has surely been sufficient to have effected this result

But the strongest argument against the theory of original deposition lies in what it fails to explain — the common presence of granite intrusions in the ore, and the amount and peculiar character of the chemical action that is shown in connection with the deposits and nowhere else in the region. If the ore is an original sediment no reason is apparent why it should so often be intruded by granite, or why it should be the locus of unusual chemical activity.

That there have been such intrusions of granite and marked chemical action is ascertained by examining the constant associate of the ore which is usually referred to as serpentine. The true character of this rock has never been known, and as it is interesting in itself and seems to have some genetic connection with the ore, a particular effort has been made to ascertain its origin. Emmons * considered it serpentine and, as already stated, classed it as an igneous rock By Shepard † it was described as a distinct mineral, Dysyntribite, and he published an analysis of a specimen from the Caledonia mines which showed a composition entirely different from that of serpentine. Later Smith and Brush ‡ presented facts to show that the material should not be classed as a mineral species, being of too uncertain composition. These investigations do not seem to have found their way into geological literature, and later writers generally refer to the rock as serpentine, though often implying a doubt as to its precise nature.

The best exposures are in the open pit of the Old Sterling mine where it forms the bottom rock. The contact between the ore and "serpentine" is most irregular, and where the ore has been removed the "serpentine" forms projecting knobs, masses and walls. In mining, the same rock is sometimes encountered cutting off the ore, but by continuing through it the ore is reached again. In short, the contact between the ore and "serpentine" is clearly an irruptive one.

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* Loc. cit.

† C. U. Shepard, Am. Jour. Sci., (2) XII, p. 209; Treatise on Mineralogy, p. 146.

‡ J. L. Smith and G. W. Brush, Amer. Jour. Sci., (2) XVI, p. 50.

The surface of the "serpentine" when fresh, is very dark green or black, more or less mottled with white spots, and, commonly, highly polished. This polishing is due to abundant slickensides which are developed on a large scale. The rock separates along these slickensides giving curved surfaces often 100, or more square feet in area, and with a wonderful lustre. Some portions of the rock, particularly where abundantly slickensided, have almost precisely the appearance of serpentine, accounting for Emmons' determination. But those parts which are mottled present a different aspect, and often strongly resemble a porphyritic rock with glassy base. Examination, both with the naked eye and with the microscope, shows that the mottling is due to the presence of abundant angular grains of granitic quartz, which are enclosed in a green aggregate of uncertain nature. From such specimens it would be impossible to get any clear idea as to the original character of the rock, and it is of such material that nearly the whole exposure consists. But fortunately there are two or three points in the pit where, over a limited area, the rock retains enough of its original character to show clearly its origin. At these points it gradually becomes lighter colored, the quartz loses its angular, fragmental appearance, and instead of the green, indefinite aggregate, pink and gray feldspar appears. The change becomes more marked toward the center of the areas till finally a coarse-grained granite is reached, between which and the "serpentine" there is a complete and gradual transition. This granite is, indeed, considerably altered, but not sufficiently so to obscure its true character. Moreover, on making inquiries of the engineer in charge of the mines, as to what underlies the ore at the bottom of the deepest shaft, he produced a specimen of the rock which proved to be a fairly fresh granite, resembling many outcrops in the region and precisely like that found in the "serpentine," only less altered. Although no extended microscopic examination has yet been made, enough has been done to show clearly that there is, as indicated in the field, a complete and gradual transition between the "serpentine" and the granite. Thus, it is evident that the so-called serpentine at the Old Sterling mine is a highly altered form of a granite which was intruded into the ore or into some other rock which has since been replaced by the ore. The "serpentine" at the Dixon mine in appearance and in origin is like that at the Old Sterling.

In the Caledonia mines the so-called serpentine is a lighter-colored rock, looking even more like a true serpentine and usually lacking the quartz fragments. It has, also, quite a different composition from that of the Sterling rock. But in spite of these differences there is such similarity in mode of occurrence and relation to the ore that it seems probable the two rocks have had a like origin. Indeed, the same may be said of the "serpentine" at nearly all of the mines, the Clark and Pike being the only clearly established exception. There the "serpentine" is decidedly laminated and contorted, differing greatly in appearance from the rock at the other mines. The microscope shows it to be an alteration of the laminated gneiss. The altered granite may also be present, but is not shown in the surface exposures.

Although this highly altered granite (or, rarely, gneiss) is a characteristic accompaniment of the ore deposits, nothing in any way resembling it has been seen elsewhere in the region, in spite of the fact that granite is a very common rock. Hence, in endeavoring to explain the origin of the ore it becomes necessary to account for the common association of granite with it; and as this granite is always greatly altered in a manner not seen elsewhere in the region, a satisfactory hypothesis must explain the presence in connection with the ore deposits, and nowhere else, of a powerful chemical agent which is capable of producing this alteration. The two hypotheses mentioned above do not offer sufficient explanation of these points. The first, that of derivation of the iron from the Potsdam sandstone, would account neither for the alteration of the granite nor for the linear arrangement of the deposits along the strike. If the second hypothesis were correct and the ore an original sedimentary deposit, why (to recall a difficulty already pointed out) should so many ore bodies be cut by granite, and what agent would be present to produce such great alteration of the granite after intrusion?

It would seem that the key to a solution of the problem must be found in the presence at or near the ore deposits of some sufficient source both of iron and of a powerful chemical agent. That such a source is at hand, a brief examination suffices to show. Near the Old Sterling mine, between it and the Dixon, a small drift has been opened in a low, broad ridge of dark, rusty-looking rock. This, on close examination, is seen to be quite variable in composition, but as a rule highly pyritiferous, the pyrite in a fresh piece constituting a considerable percentage of the rock. The pyrite is sometimes replaced by a black mineral which proves to be magnetite. That the rock is profoundly affected by weathering is shown by the abundant presence of portions from which the pyrite has been entirely removed by oxidation, changing a heavy, compact rock to a light-gray, porous mass, somewhat resembling pumice.

This oxidation sets in circulation dilute solutions of ferrous and ferric sulphate and sulphuric acid. In other words, these pyritiferous gneisses are precisely what is needed to afford a source of iron and a powerful chemical agent, whose action is confined to a limited area. When it comes to using these rocks as an explanation of the ore deposits, difficulties are encountered similar to those met with in investigating the origin of the "serpentine." For while at some mines the pyrite rocks are prominent, at others outcrops fail, and the presence of these rocks can only be inferred. But as they may always be found in the vicinity of the mines, this inference seems to be fully justified.

The pyritiferous gneisses standing at a greater or less angle in the limestone series would, as above stated, supply, at and near the surface, dilute solutions of iron sulphates and sulphuric acid. A portion of these solutions would pass away in surface drainage waters; another portion would sink down, with a tendency to follow the dip, and where it came in contact with limestone would produce double decomposition, the iron being precipitated as carbonate or hydrated oxide and the lime and magnesia going into solution as sulphates.* This decomposition of limestone by the ferruginous solutions would be promoted by the presence of any impervious mass which would check the downward flow of the solutions and cause them to spread laterally. Such a mass would be found in granite cutting through the pyritiferous rocks and limestone, which explains the common association of ore and

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*F. P. Dunnington.—On the formation of deposits of Oxides of Manganese, Amer. Jour. Sci. (3) XXXVI, p. 177.

granite. The same end might be sometimes accomplished by the gneiss, when the structure was favorable.

At the same time the solutions of iron, calcium and magnesium sulphate, and of sulphuric acid would afford a very powerful agent for the alteration of the granite, or gneiss, whose action would be limited to the vicinity of the ore deposits. The accompanying analyses give an idea of what this chemical change has been. Its extent can be appreciated only by considering the fact that the original granite was very acid, containing practically no ferro-magnesian constituents. That so profound an alteration indicates the action of some special agent will hardly be questioned. The wide variation in composition of the two samples is striking, but no more than might result from variations in the complicated processes of alteration. The Old Sterling rock has, perhaps, the most remarkable composition, considering its origin, and points clearly to ferruginous and magnesian solutions as the agent of change. As shown by analysis I, it has lost silica and alkalies, and has taken up water, magnesia and a remarkable amount of iron. In the case of the Caledonia rock the changes are less extensive, though still marked. Hydration, loss of silica and relative gain of alumina are shown, while there is a notable retention of alkali. This is unusual as the alkalies are generally among the first constituents removed in the alteration of such rocks. No cause for the exception in the present case has yet been found.

The altered rocks show much evidence of having been subjected to pressure, with resulting shearing. That this has aided the process of alteration, particularly by crushing the constituents, the facts seem to indicate. Thus, at the Caledonia mine where the quartz has almost entirely disappeared, the rock is decidedly slaty, which has given rise to the idea that it is an altered sediment. It is probable that the rock movements producing the slickensides at the Old Sterling mine have, in large part, resulted from change of bulk attendant upon chemical alteration, as suggested by Diller* in the case of serpentine.

As to the mineralogical affinities of the two rocks, the Caledonia variety is related to muscovite in composition, and Dana gives an analysis of it among the varieties of pinite. The Old

* J. S. Diller, Geology of the Lassen Peak District, 8th Ann. Report, U. S. G. S., I, p. 401.

Sterling variety is most closely related to the chlorites, though in some respects resembling the rather obscure hydrous silicates, hisingerite, gillingite, jollyite, etc. It is important to note that Roth* describes these as minerals which are formed where pyrite decomposes in the presence of silicates. This fact of a general nature lends additional strength to the theory here advanced.

	I.	II.	III.
$Si\,O_2$	29.70	46.90	46.70
$A_2\,O_3$	17.03	35.73	31.01
$Fe\,O$	27.15	2.48	3.69
$Mg\,O$	10.66	0.83	0.50
$Ca\,O$	1.68	0.45	Trace.
$Na_2\,O$	0.56	0.48	Trace.
$K_2\,O$	0.10	6.41	11.68
$H_2\,O$	11.79	5.00	5.30
	98.63	98.88	98.88

I. "Serpentine," altèred granite, Old Sterling mine.
II. "Serpentine," presumably altered granite, Caledonia mine.
III. "Dysyntribite." (Smith and Brush.)

In the writer's analyses, I and II, though all of the iron is calculated as ferrous oxide, a minor portion of it is present in the form of ferric oxide. There is sulphuric acid present also in both samples, as shown by qualitative tests. These two factors, if reckoned in, would materially increase the totals shown above. Analysis III, of the Dysyntribite of Shepard, is introduced for comparison.

The chemistry of the process of ore formation is quite simple, involving only familiar reactions, well known both in laboratory and field. The resulting ore would be limonite, and siderite, which would be changed to limonite by oxidation as continued

* J. Roth, Allgemeine und Chemische Geologie, Bd. I, p. 238.

erosion brought the ore body more within reach of surface waters. The passage of limonite into hematite is probably often spontaneous,* but in the present instance it is sufficiently accounted for by the movements to which the ore has been subjected in connection with the folding of the overlying Potsdam sandstone, and very probably also by movements of earlier date. The highly crystalline hematites, of which specimens are seen in mineral collections, occur in small pockets, none of which have come under the writer's observation. They may be older bodies which have been subjected to the same metamorphism as have the Oswegatchie rocks, or may have resulted from some peculiar conditions of precipitation. In this connection it is interesting to note that the cavities of the Old Sterling ore are lined with tabular crystals having the form and appearance of hematite. Examination of a large number of specimens has shown that these crystals are often strongly attracted by the magnet and have a jet black streak. They dissolve quite readily in hydrochloric acid, and the solution gives a nearly black precipitate with ammonic hydrate.† These facts indicate that the crystals are pseudomorphs of magnetite after hematite. This change has doubtless been effected by solutions of a reducing nature, which have also deposited rhombohedrons of siderite and the well-known millerite within the cavities.

The theory of ore formation thus outlined, points to a source of iron, explains its common accumulation on bodies of granite, and gives a cause for the alteration of the granite. It also accounts for the structure and variation of the ore; and not only for the irregular shape of the ore bodies but also for their linear distribution along the strike, the former resulting from their mode of concentration, the latter from their derivation from the apparently interbedded pyritiferous layers.

With the form, structure and distribution of the ore bodies and their association with altered granite accounted for, there remains to be explained only the constant presence of sandstone resting upon the ore. To find a reason for this it is necessary to consider what were the topographic conditions at the beginning of the Potsdam period. The region was doubtless of rather low

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* W. O. Crosby, Amer. Geologist, VIII, p. 72.

† Compare Tschermak's Lehrbuch der Mineralogie, p. 413.

relief, and there can be no doubt that then, as now, the gneiss formed the higher and the limestone the lower areas. That this was so is not only inferred, but is shown by direct evidence in the present relation of sandstone beds to gneiss and limestone. Now, in this limestone, the ore was forming by the process outlined above. As the country approached more closely to a base-level any deposits formed at elevated points would be destroyed, being in part removed by erosion and in part working down to form deeper-seated accumulations. Thus, when the Potsdam sea spread over the region there would be left only such deposits as had been formed below the last land surface, and these would all be in depressions. Being covered by the sea, the whole area received a thick coating of sandstone, which filled up all depressions and produced a surface approximately flat. Were there had previously been a depression the sandstone would be thickest, and where there had been an elevation it would be thinnest.

The region being again elevated, denudation began. As a result of this denudation the once extensive and continuous sheet of sandstone is reduced to a number of scattered patches. It is only natural that these patches should be left where the sandstone was originally thickest; in other words, where it had to fill up depressions. As the ore was deposited in such depressions it is not surprising that sandstone should be found resting upon it. A further agency which would tend to produce the same result is underground drainage. After the sandstone was cut down to the limestone, at many points water would be removed through underground channels, and would have little erosive effect upon the scattered patches of sandstone. The fact that the lower layers of sandstone become ferruginous and grade into the ore, is what would necessarily result from the deposition of the former upon the latter, the sandstone deriving a portion of its material from the ore. In fact, at the Old Sterling mine the sandstone just above the ore contains distinct pebbles of the latter.

If this explanation of the cause of association of sandstone and ore is correct, it would be expected that sandstone would be less common in gneissic areas than in limestone areas, the gneiss being assumed to have formed the elevated portions of the sea bottom upon which the sandstone was deposited, and hence to have received a thinner layer. As a matter of fact this is precisely the case, for thus far very few outcrops of sandstone have been seen within the gneissic areas. This fact is well shown on the map.

It may be well to sum up briefly the foregoing conclusions. If the iron ores be regarded as formed by the replacement of limestone by iron derived from decomposing pyrite, a sufficient explanation is afforded for the form, character and distribution of the deposits, for the association of granite with many of them, for an unusual alteration of this granite, and for the presence of Potsdam sandstone resting upon the ore. Of the other theories suggested, while each explains some of these facts, neither one satisfactorily explains all of them. The weak point in the theory advanced lies in the unavoidable scantiness of data upon which it is based, and the writer fully realizes that it may be proved untenable by more extended investigation. It has been presented at some length, because it seems to afford the most rational explanation of the facts thus far observed, bringing them into clear and definite relation with each other. This certainly gives it a right to be accepted as a working hypothesis, to be retained until disproved.

That the hypothesis is not in the least a novel one need hardly be said, for the same explanation has been applied to a great many ore deposits in various parts of the world. It would be useless to try to cite all of these cases, but a few may be briefly mentioned. Many of the limonites of the Great Valley have been ascribed to the replacement of limestone by iron derived from oxidizing pyrite, and Prime * in describing the deposits of Lehigh county, Pennsylvania, outlines the process in almost the same words used above by the writer. The main difference in the two localities is that the Pennsylvania deposits have damourite slate instead of granite as the underlying impervious rock. Emmons † in his classic monograph on the Leadville region describes limonite and hematite of similar origin, the iron coming from pyrite and replacing limestone. The hematites of the Marquette district, Lake Superior, as shown by Van Hise,‡ have been formed by a different process of

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* F. Prime, Jr., On the occurrence of brown hematite deposits of the Great Valley, Amer. Jour. Sci. (3) IX, p. 433.

† S. F. Emmons. U. S. G. S. Monograph, XII, pp. 499, 547.

‡ C. R. Van Hise, The Iron Ores of the Marquette District, Michigan, Amer. Jour. Sci. (3) XLIII, p. 116.

concentration. But they are precisely like the ores under consideration in one respect, that is in being concentrated upon an impervious rock. Moreover this is usually an altered igneous rock, diabase or diorite, which the miners call "paint rock." Thus, the analogy in this direction is quite complete, the altered diabase or "paint rock" corresponding in position and function with the altered granite or "serpentine."

The facts in regard to the past productiveness of this region having been given by Dr. Smock,* it is unnecessary to repeat them here. As already stated, the mines are now idle and their future depends upon so many conditions that it would be useless to speculate at length in regard to it. Of course the recent developments of the great iron regions of the West and South has a tendency to check the working of the more limited deposits. And yet these ores have long enjoyed an excellent reputation as helping to make a favorable mixture in the blast furnace, and for this purpose have been transported considerable distances. In view of these facts, and as the ore may be cheaply mined, it is very probable that when the present depression in the iron trade is over, working of the mines will be resumed.

Talc.

Within recent years an important industry has developed, based upon a remarkable series of talc deposits, which, though largely outside of the region examined, extends into its southeastern corner. In that part of the map there is shown a belt of limestone, including a mass of gneiss which is rich in hornblende and nearly black. This belt stretches over into the town of Edwards, but has not been examined in that portion. The appearance of the limestone is quite different from that seen in the larger areas to the north, as it contains abundant thin layers of a fine-grained, white substance, which withstands the weather, forming projecting edges. At the same time the limestone often appears less crystalline than that seen elsewhere. The composition of these layers has not been thoroughly investigated, but a single section shows tremolite and colorless pyroxene as the chief constituents. In association with these layers thick beds of quite pure talc are developed upon a large scale. They are often several feet in

* J. C. Smock, Bull. N. Y. State Museum, No. 7, pp. 44, et seq.

thickness and remarkably free from injurious admixture. At the surface these beds are discolored, but further down become a clear, greenish white, and have a scaly or fibrous structure.

In seeking the origin of these deposits, their structure and relations to surrounding rock, their composition and the occurrence of analogous deposits in other portions of the region are to be considered. All of the talc deposits examined lie in that portion of the belt shown on the map, and these, in every case, are in the limestone. They form beds lying in this rock and show every evidence of being interstratified deposits. Nothing was seen to indicate that the talc bodies are veins, though they are commonly referred to as such. In working the deposits masses are sometimes struck consisting largely of tremolite, which, as stated by Sahlen,* has given rise to the theory that the talc is derived from amphibole. The presence of these tremolite masses certainly points strongly to such an origin, as does also the fibrous structure of the talc. To get further evidence upon this point, sections were prepared from specimens of the fibrous talc, an effort being made to procure a fairly complete series from soft talc to tremolite. Under the microscope these sections all show the presence of tremolite. The harder varieties contain nothing else excepting quartz, to which mineral the hardness is doubtless largely due. Even the softest specimens are seen to be largely composed of very finely fibrous tremolite, probably somewhat altered, with high interference colors and extinction angle of sixteen to eighteen degrees. Thus it seems that much that is called talc contains in reality considerable tremolite, only the scaly varieties being true talc. Microscopic evidence then strongly supports the theory that the talc is derived from tremolite. When to this is added the fact already stated that the crystalline limestone elsewhere in the region shows tremolitic varieties which pass into tremolite schist, the evidence becomes practically conclusive.

The tremolite schists represent portions of the limestone formation which contained a large amount of silicious sediment. Metamorphism produced crystallization of the mingled calcareous,

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* A. Sahlen.—The Talc Industry of the Gouverneur District, N. Y., Trans. Am. Inst. Min. Eng., XXI, p. 583; The Mineral Industry, I, p. 435.

magnesian and silicious materials, forming tremolite. Where the calcareous material was in considerable quantity there was formed a tremolite limestone; where it was a minor constituent there was formed a tremolite schist. Under the influence of subterranean waters chemical changes have been produced. The tremolite has taken up the elements of water, the lime has passed away into solution, and talc has resulted. At the same time any calcite associated with the tremolite would be removed, rendering the talc bed more pure While tremolite seems to have been the predominant source of talc it is highly probable that some actinolite and varieties of pyroxene have entered into the process, as they might well be present and would be similarly affected. The essential agent for such chemical changes is water containing carbon dioxide in solution, an agent so widely diffused as to render unnecessary any special explanation of its presence in this instance. The operation may have been aided by the presence of magnesia in the solution, but of this there is no positive evidence.

This process of talc formation is so familiar, in the production of talc pseudomorphs after amphibole and pyroxenes and in the formation elsewhere of considerable talc deposits that it is unnecessary to refer to particular instances. Descriptions of such occurrences may be found in Dana's System of Mineralogy, in Roth's Allgemeine and Chemische Geologie and in other works of a similar nature. That the process is one of common occurrence is an additional argument in favor of the views advanced.

Though the talc is abundant in the belt now worked, the belt is itself rather limited — only eight or ten miles long and a mile or less wide. It, therefore, becomes important to determine whether or not it is to be found outside of this belt The presence of tremolite layers in various parts of the limestone area suggests that talc may occur, and some prospecting has been done, but thus far without success. It must be remembered that while tremolite may change to talc, it will do so only when the conditions are right, and, therefore, the occurrence of tremolite is no proof of the presence of talc. Moreover, the peculiar character possessed by the limestone of the talc belt, described above, is repeated nowhere else in the region examined, and, as it seems a justifiable inference that this character has a genetic connection with the talc, its absence may be regarded as indicating a probable absence of important talc deposits. On the other hand, should limestone of this character be found in other parts of the region it would point to a very strong probability that a search for talc would be rewarded.

Mr. J. L. Sparks, superintendent of the Asbestos Pulp Company, Gouverneur, has kindly supplied the following estimates in regard to the output of the district during 1893: Talc mined, 38,000 tons; cost of mining, one dollar to two dollars per ton; average selling price of finished product, eight dollars per ton.

The product of the mines is ground to a fine flour in mills on the Oswegatchie river in the vicinity of Gouverneur, which village is the distributing point of the entire district. Within the past year a line of railroad has been constructed from the Rome, Watertown and Ogdensburgh road at Gouverneur to Edwards, running through the talc belt, and greatly reducing the cost of transportation, which was formerly carried on in wagons over very bad roads. At the same time competing interests have been united, so that in the future the development of the talc will probably proceed on a much larger scale. As the product of the mines is of a quality unequaled by that of any other region it finds a ready sale. A very large percentage of the talc is used in the manufacture of paper, smaller quantities going into soap, paint and the adulteration of various white powders.

Marble.

When the crystalline limestone is free from disseminated minerals, and has a uniform color and grain, it makes a handsome marble. The best variety is coarse grained, and of a dark gray color. Just west of Gouverneur, beside the Rome, Watertown and Ogdensburgh tracks, three large quarries are worked in this rock, and a fourth is located two miles northwest, reached by a switch from the main line of the railroad. The stone is worked out by means of vertical channeling and a nearly horizontal series of joints. Large blocks are removed and then sawed to required sizes in mills adjacent to the quarries. The stone is used chiefly for building purposes, and, with a rock finish, is very handsome, presenting a soft gray surface, not unlike certain granites. Its uniformity of texture and composition render it very durable, and there can be no doubt that it will always be in demand as a building material. While it is true that most of the limestone of the region contains impurities which unfit it for building purposes, still the extent of the rock is great enough to warrant the assumption that there must be very large quantities of good marble yet to be exploited.*

Respectfully yours,

C. H. SMYTH, Jr.

Hamilton College, Clinton, N. Y., *January*, 1894.

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* For further details see Bulletin of the N. Y. State Museum, No. 3, by J. C. Smock.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

Geology of Cattaraugus and Chautauqua Counties.

JAMES HALL, State Geologist. | F. A. RANDALL, Assistant.

1892-1893.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Preliminary Report on the Geology of Cattaraugus and Chautauqua Counties.

By F. A. Randall.

Warren, Penn., *January* 8, 1894.

Prof. James Hall, *State Geologist:*

Sir.—I herewith send diagrams and sections made along the valley of Tuna creek, Red House creek and Quaker run and their tributaries, including also data in hand north of Salamanca to Rock City. I have placed upon the diagram the section of the Dennis oil well at Bradford, which was very carefully measured while drilling, by Mr. Carll's assistant. It shows the Pope Hollow rock at 1840 feet and twenty-three feet thick.

Panama Conglomerate.

The Panama rock is not indicated by a conglomerate or coarse sandstone; I did not find it in the Tuna valley nearer than Bailett's brook (section G), six and one-half miles south of the oil well, but from this north and west on Tuna creek, Red House creek and Quaker run it is present. From this I infer that it thins out and is replaced by finer material going south, as it is in Warren county, Pennsylvania, and Chautauqua county, New York, but not extending as far south at the east as in Warren county, Pennsylvania. It is only five feet thick at

Ackley on the Conewango, two miles south of the State line. East of Fentonville just north of the State line it is at least fifteen feet thick. At Corydon on the Allegany river, at the State line, it is sixteen feet thick and maintains this thickness, going north from this point. On Quaker run, Red House creek and along the Tuna creek it is about fifteen feet thick as far as I have traced it. At a rock city, about three quarters of a mile northeast of Carrollton, it is twelve feet thick, massive and pebbly all through. This is the most northeasterly locality where it was seen. On the west side of the Red House creek, five and a half miles north of the State line (section K), it is twenty feet thick. This is at the same latitude as the exposure at Panama, where it is sixty-nine feet thick and where it attains its maximum thickness.

Pope Hollow Rock.

This rock is well developed throughout the district surveyed. It is about twenty feet thick and is a sandstone with flat pebbles, but contains fewer pebbles than the Panama rock. In the Bradford oil well it is very distinctly shown, "a sandstone with few pebbles." North of this there are numerous exposures in the hills bordering the Tuna valley. On Limestone brook (section E) it makes vertical cliffs and also near the head of Irish brook (section F, Rice brook). It is also indistinctly shown on the north face of Bald mountain south of Limestone (section C). At "rock city," northeast of Carrollton, it is seen lying above the Panama rock. East of Irvine Mills a similar rock is seen, but the elevation seems to be too great, 2110 feet. This is only twenty-one feet lower than the exposure northeast of Carrollton, two and three-quarter miles farther north. I think this is the nineteen feet of sandstone which lies above the Pope Hollow rock at Warren, Pennsylvania, of which I have seen indications through Chautauqua and Cattaraugus counties, New York. This rock is again seen at the head of Bailett's brook (section G), one and three-quarter miles south of Irvine Mills. I did not find an exposure of the Pope Hollow rock on the Red House creek or Quaker run, but have no doubt that it is there, and that future search will reveal it.

Sub-Olean Conglomerate (Waverly).

On the top of Buchanan hill (section B), one mile south of the State line, is seen a flat-pebble conglomerate, which probably represents this rock, as it is at about the right elevation. The only other exposure seen was near the head of a north branch of Quaker run (section H), four miles north of the State line and ten miles west of the above locality. A line drawn between these two exposures runs fifty or sixty feet beneath the base of the Olean conglomerate, about its normal position.

Olean Conglomerate.

This rock was found at three points only; at the headwaters of Nichol's run (section D), about four miles east of Limestone station and three miles north of the State line, and at the head of Irish brook (section F), west of the Tuna creek and northwest of Limestone station. At the Nichol's run exposure (section D) it is fifty-six feet thick, massive, crowded with large and small oval pebbles and capped by a coarse gray sandstone. There are several exposures here around the head of the stream. This exposure is about one-half a mile north and five miles west of the Olean rock city. At the Irish run exposure (section F) it is equally massive, and as it caps the hill it forms a rock city of small extent. It stands out in huge blocks thirty or forty feet thick, the tops of which are inaccessible, but I judge that no sandstone remains upon it. I did not see the sub-Olean conglomerate below it.

Red Rocks.

There are three distinct strata of red rocks shown upon the diagrams, which seem to occupy the same horizon for several miles north of the State line, and which are also represented in the Bradford oil well, the upper one being directly over the Pope Hollow rock. This layer extends eight and one half miles north of the State line, where it is seen at the Big Trestle, two and three quarter miles southeast of Salamanca (section P); it is here at least fifteen feet thick. In the oil well at Bradford it is eighteen feet thick. It was also found on Nichol's run, four miles east of Limestone station (section D–1). Also on Irish brook, three and one-half miles northwest of Limestone (section F.) Here its upper surface is twenty-five feet above the Pope Hollow rock, but the entire thickness could not be ascertained. It was again seen on the east side of Red House creek (section I). It evidently lies just above the Pope Hollow creek. While in the field there seemed to be so many horizons of red rock that I did not appreciate their importance but simply took the elevations. Not until they were placed upon the diagram was I certain that they were extensions of the same band.

There is a lower red rock shown in the Bradford oil well, also on Buchanan hill (section B), Bald mountain (section C), and on Nichol's run (section D--1). About 550 feet below the Pope Hollow rock in the Bradford oil well is another red horizon. On Quaker run (section S) a red rock was seen underlaid by flags; also just south of Carrollton a red rock is visible (section O). Faint traces of a red shale were seen north of Salamanca at the water-works. These may possibly be of the same horizon, but it needs further study to confirm this point. I have placed upon the diagram the section (M) on Gray's run, southeast of Steamburgh and west of the Allegany river where the Elko mine red rock and Panama conglomerate outcrop, to show its close agreement with this interpretation of the geological structure.

Mauch Chunk Red Shale.

The Second Geological Survey of Pennsylvania, in its report upon McKean county, says that the Mauch Chunk red shale was not found except in the southeastern portion of that county.

In my investigation in Cattaraugus county no red rock lying beneath the Olean conglomerate was seen except at one locality, viz.: at the head of Irish run, four miles northeast of Limestone station. Here a very red thin-bedded micaceous layer is seen capping the hill, twenty-five feet below the base of the Olean conglomerate which forms a rock city 150 yards away. In consequence of its position the thickness could not be ascertained, but I should estimate it at from five to ten feet. It appears to contain obscure vegetable remains; one-half mile west of this I found a loose block that resembles it closely, but fifty feet lower, containing a *Rhynchonella*. Whether this is Mauch Chunk rock or not I can not say but it is worth further investigation. It is possible that it may be found at other points where the Olean conglomerate outcrops.

The Region North of Salamanca.

Hitherto I have not spoken of the rocks north of Salamanca. Between the most northern outcrops of the conglomerates actually seen along the Tuna and Red House creeks and the outcrops north of Salamanca there is an interval of four miles in which I did not find the conglomerates, but vast quantities strew the north face of the hill south of Salamanca, and many deep ravines extend north from the Red House creek, so that I have no doubt but that a more careful survey would reveal them, thus making a complete connection with the rocks north of Salamanca. One mile north of Salamanca and east of the water reservoir the ridge is capped by a massive conglomerate twenty-five to thirty feet thick, whose top is 2140 feet A. T. The upper layer is a yellowish fine-grained sandstone and has upon the upper surface numerous impressions of *Hippodophycus*. In my hurried visit I did not see any conglomerate below this. About two miles north of this is the celebrated rock city, elevation 2190 feet A. T., showing a dip of about twenty-five feet per mile. About one-half mile northwest of Mr. Brown's house I found an outcrop of conglomerate, nine feet thick, top at 2147 feet A. T. There is some uncertainty as to just where the Pennsylvania geologists took their elevation of "2190 top," but from the best information obtainable I judge it was east of this point. If so this may be a lower rock than the "rock city" and possibly may represent the Warren sandstone lying below the Pope Hollow conglomerate. According to these elevations there is an interval of twenty feet. No conglomerate was with certainty found below this.

Just west of the road near the township line and one-quarter of a mile south of Horace Brown's house is an outcrop of red shale overlaid by a green sandy shale (top of red shale 2018 feet). This would put it 175 feet below the top of the conglomerate. At Pope Hollow this interval is 200 feet; at the Elko paint mine 190 feet and at Warren 200 feet. This is assuming that they are the same rock, and from my examinations of it I believe it is the same horizon. The red shale and the green rock resemble that at the other localities very closely. The difference in the intervals is not surprising when we consider the distance.

Should this prove to be the red rock assumed the conglomerate must be the Pope Hollow rock. From the nearest exposure of the Panama conglomerate the rise required to bring it up to the conglomerate would be forty-five feet per mile. This is fifteen feet per mile greater dip than I have observed anywhere in Cattaraugus or Chautauqua counties. The rise of the Pope Hollow rock from the same outcrop would be only fifteen and one-half feet per mile, but the interval here between the Panama rock and the Pope Hollow rocks is greater than usual.

In view of these facts an absolute conclusion can not be drawn. It will require a few days' work over the interval between Red House creek and the rock city. This done I think there would be no difficulty in determining the question without chance of error. It seems to me probable, however, that the Salamanca rock is of the same horizon as the "Pope Hollow conglomerate."

In regard to the map work, I have about finished it on both sides of the Tuna creek as far north as Windfall run, one mile north of Carrollton and running about three to four miles east of the Tuna. West of the Tuna creek to one mile west of Red House creek the work is nearly completed, and also south of Red House creek two miles south to the Alleghany river. I also covered considerable territory upon the lower part of Quaker run. All of the higher hills will take in the Waverly south of Red House creek and also along the Tuna creek nearly as far north as the Alleghany river. I think there may be a small area two miles southeast of Salamanca but am not positive. It is 2260 feet A. T., and to determine its horizon it will be necessary to either get a measurement from the Panama or Pope Hollow rocks or find fossils. Bald mountain, one mile south of Limestone (section C), seems to be high enough to be capped by the Olean conglomerate but I did not find it. As it is some distance south of other exposures of the Olean conglomerate it may be concealed below the summit (2321 feet).

The high knob east of Carrollton is capped by Waverly (2356 feet). I think that all of the highest peaks near the State line will prove to be of the Olean conglomerate.

Diagrammatic Section.

This is made along the Tuna creek from Bradford to and including the Salamanca rock city. The exposures upon the line are placed at their actual elevation and latitude. Those east or west of it are all projected upon this line. As the dip of the rocks is about eleven degrees west of south, the sections are raised five feet per mile when west, and lowered five feet per mile when east of the line. When tested by sections east and west each proves to be quite accurate. A broken line running from section to section indicates the equivalency of the horizons. We now have a line of sections both east and west of Salamanca.

I also inclose a list of the sections showing the actual elevation, the allowance made for eastern rise or western fall and the elevation on the diagram.

All of which is respectfully submitted.

Very truly yours,

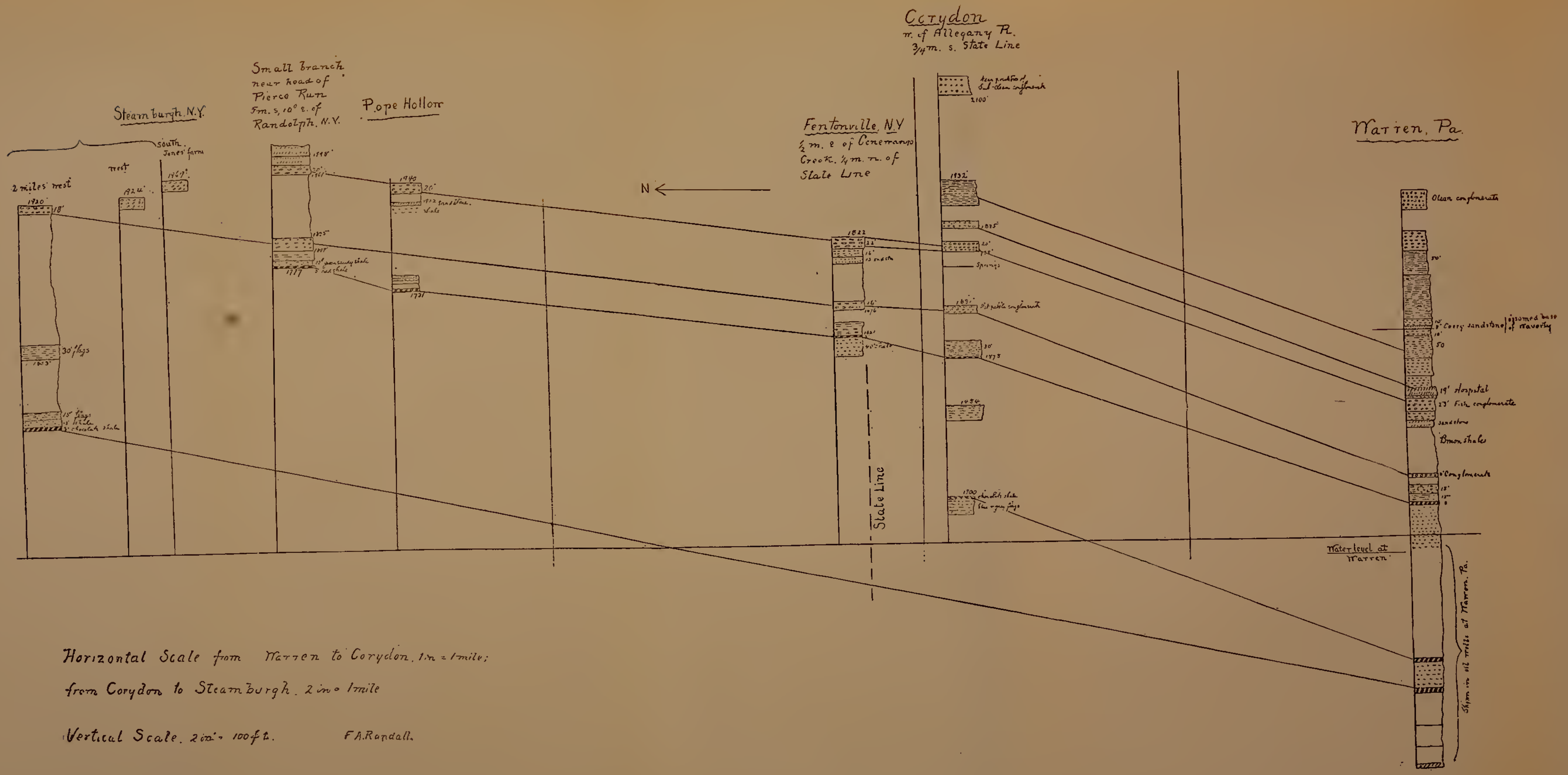
F. A. RANDALL.

Sections on a north and south line along Tuna creek, Red House creek and Quaker run, Cattaraugus county.

		Actual elevation A. T.	Allowed for rise or fall 5' per mile.	Elevation on diagram.
A.	Dennis oil well, Bradford.			
	Pope Hollow conglomerate	1840	0	1840
B.	Buchanan hill, west side Tuna, 1 mile south State line.			
	Pope Hollow rock, top	1897	0	1897
C.	Bald mountain, 1 mile south of Limestone.			
	Red shale	1851	0	1850
	Top Pope Hollow conglomerate	1953	0	1953
	Top of hill capped by drab flags, high enough to be Olean conglomerate	2321	0	2321
	Olean Rock City, base	2340	40	2300
D-1	Nichol's run, south branch.			
	Red shale, A. lower	1888	16	1872
	Red shale, B. upper	1969	16	1953
D–2	Olean conglomerate, north branch, base	2331	16	2315
E.	Limestone brook, west of Tuna creek.			
	Pope hollow conglomerate	1961	12	1973
F.	Head of Irish brook (south branch, "Rice brook").			
	Conglomerate (Pope hollow), top	2000	12	2012
	Red shale	2030	12	2042
	Olean conglomerate, base	2299	12	2311
	Red shale (Mauch Chunk?)	2275	12	2263
G.	Bailett's brook east of Tuna, 1 mile north of limestone.			
	Top of conglomerate	2061	5	2056
	Top of conglomerate (Panama conglomerate)	1860	0	1860
S.	Quaker run, 1 mile east of mouth of stream (first bridge).			
	Red shale underlaid by 15 feet of flags	1329	61	1390
H.	North branch of Quaker run.			
	Conglomerate top; Panama rock	1820	50	1870
	Conglomerate top; sub-Olean conglomerate	2229	50	2279
I.	Red House creek; Bosworth brook, south-east of C. N. Bosworth's house.			
	Red shale	2075	13	2088
J.	Irvine mills east of Tuna creek.			
	Conglomerate; top seems to be too high for Pope hollow	2110	......	2110
K.	Red House creek (Frantz farm).			
	Conglomerate (Panama) top	1879	18	1897

Sections on a north and south line along Tuna creek – (Continued).

		Actual elevation A. T.	Allowed for rise or fall 5' per mile.	Elevation on diagram.
L.	Head of Reynold's run (a south branch of Red House creek).			
	Conglomerate (Panama) top	1908	37	1945
M.	Gray's run, west of Alleghany river.			
	Red shale overlaid by green sand, horizon of Elko Paint mine	1794	71	1865
	Conglomerate (Panama) top	1854	68	1922
N.	South Carrollton run, west of South Carrollton.			
	Conglomerate (Panama) top	1927	10	1937
O.	Carrollton, northeast of.			
	Conglomerate (Pope Hollow rock) top..	2131	0	2131
	Conglomerate (Panama) top	1975	0	1975
	At base of section red rock and flags...	1441	0	1441
	Capped by drab flags in high knob east of Carrollton...	2356	0	2356
P.	Big trestle on Patterson's tram railroad, 2½ miles south by east of Salamanca.			
	Red shale top......................	2145	18'	2163
	Gray sandy shale (Chemung)	2181	11'	2192
Q.	East of water-works, 1 mile north of Salamanca.			
	Base of section at reservoir...........	1480	20'	1500
	Top of conglomerate, east of reservoir, upper layer of sandstone	2140	20	2160
R.	Salamanca Rock city.			
	Top of conglomerate (35 feet thick) ...	2190	20'	2210
	Base of conglomerate, 9 feet thick, north by west of Brown's....	2128	20	2148
	Red shale south of Brown's, capped by green shale; top....................	2018	20	2038



Horizontal Scale from Warren to Corydon. 1 in = 1 mile;

from Corydon to Steamburgh. 2 in = 1 mile

Vertical Scale. 2 in = 100 ft.

F.A. Randall.

Sections along Tuna Creek, Red House Creek and Quaker Run.
By F. A. Randall
Scale; vertical, 1" = 100'; horizontal, 2" = 1 mile
R
Salamanca Rock City
Q
E. of Waterworks 1 m. nw of Salamanca.
P
Big Trestle, 2¾ m s. e. of Salamanca
O
Northeast of Carrollton
N
South Carrollton Run
M
Gray's Run
L
Head of Reynold's Run south of Red House Creek
K
J
Irvine Mills
I
Southeast of Red House Creek
H
S
Quaker Run
G
Bailey Brook
F
Head of Irish Brook
E
Limestone Brook
D-2
D-1
Nichol's Run
Olean Rock City
C
Bald Mt.
State Line
B
Buchanan Hill
A
Dennis Oil well Bradford Pa
Olean conglomerate
Sub-Olean conglomerate
rise 15½' per mile
rise 45' per mile required to prove "Panama" to be "Salamanca"
rise 24' per mile
Warren and Elk paint mine red shale
Pope Hollow Rock
Panama Rock
grey flags
R.R. at Salamanca
2140
2131
2015
1975
1973
1953
1897
1860
1842
1441'
1200' A.T.
11' sandy shale
33' fine grey sandstone
19' dark grey shale
48' blue slate
16' dark grey slate
24' bluish slate
39' olive grey sandstone
35' fine grey sandstone
38' sandy slate
95' slate
71' dark grey thin bedded sandstone
23' very fine sandstone
26' dark grey sandstone
63' fine micaceous sandstone
13' sandstone

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK

(GEOLOGICAL MAP.)

REPORT

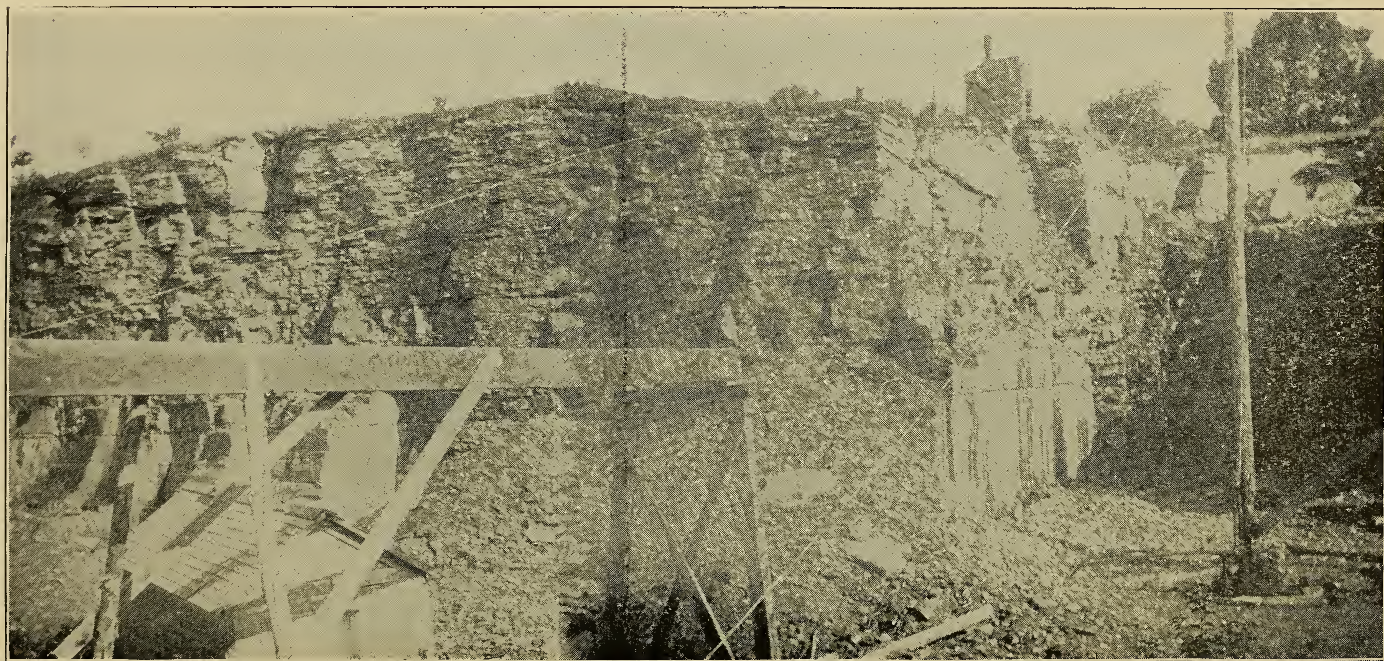
ON

FIELD-WORK IN CHENANGO COUNTY.

JAMES HALL, State Geologist. | J. M. CLARKE, Assistant.

1893.

PLATE 1.



Station D. Quarry at Top of Hill, One and a Half Miles West of Norwich. Flags and Shales of the Oneonta Group.

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

Report on Field-work in Chenango County.

By J. M. CLARKE.

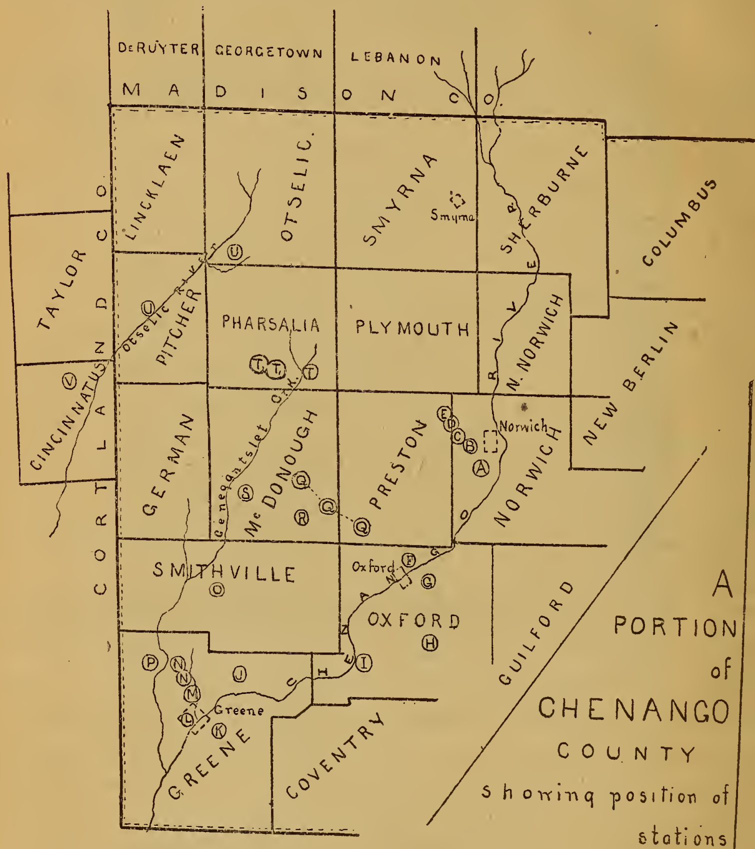
Prof. James Hall, *State Geologist:*

Sir.—The report which I am able to make of my field explorations during the month of September, 1893, in Chenango county will of necessity be brief and incomplete. Starting into the field with the hope of accomplishing a given amount of work within a specified time it was my misfortune to have both elements in the plan miscarry, first on account of the advent of protracted rainy weather and second from the demands of prior duties at the Albany office.

This work was undertaken with the purpose of acquiring further evidence as to the relation of the Oneonta sandstone and shales to the underlying rocks, the nature of the fauna of these rocks, the western continuation of the red and grey sandstones or red and green shales of the Oneonta, from their typical exposures in Otsego county and the determination of the easternmost appearance of the typical marine Portage fauna. Concerning the first two of these points the information acquired is here duly set forth, but the last is a matter still to be determined.

Without entering into the history of the discussions pertaining to the position of the Oneonta shales and sandstones (Vanuxem) in the New York series it may be stated that it has of late years been regarded as resting upon rocks containing a Hamilton fauna (a determination of unquestionable accuracy) and hence as representing an eastward extension of the Portage group of western New York.

Just as I was starting into the field there appeared in the American Journal of Science for September an important paper by Prof. C. S. Prosser, on the very section that I was then to study, entitled "The Upper Hamilton and Portage Stages of Central and Eastern New York." Much to my regret I knew nothing of the existence of this paper until after my return;



could it have been in my hands during the explorations in the Chenango valley it would have been of great service. This paper puts forth the view, supported by a well-constructed argument, that the fauna lying beneath the Oneonta shales and sandstones is a Hamilton fauna only in the sense that it contains a considerable number of Hamilton species, whose typical expression is often more or less modified; that it lies above the horizon of the Tully limestone and Genesee shales, as indicated by their easternmost outcrops near the village of Smyrna in the upper part of the valley, and is hence representative of the Portage group. Inferentially this argument ascribes to the Oneonta deposits a supra-Portage or Chemung equivalence. I may briefly refer again to Prof. Prosser's observations.

The plan of my field work was to follow meridional sections westward from the Chenango river, through Chenango and Cortland counties; the observations made, however, pertain almost wholly to Chenango county. In presenting these traverses I have not followed the order in which they were made, but have arranged them from north to south along the Chenango valley with westward departures.

Station A. One and one-half miles south of Norwich on the valley road; exposure along the roadside on the property of William Breed; about fourteen feet thick where opened. At the base of this exposure are three feet of a softish gray sandstone overlaid for the entire height of the section by shaly sandstones and soft shales. All of the softer and shaly beds are permeated with Hamilton fossils, viz.:

Phacops rana, not uncommon; one large, extended and typical specimen.

Homalonotus DeKayi.

Sphœnomya cuneata, the large and typical form.

Leptodesma Rogersi, normal; common.

Actinopteria Boydi, small form.

Goniophora rugosa, common.

Microdon bellistriatus, common.

Paracyclas lirata, common.

Cimitaria elongata, small form; rare.

Schizodus appressus, rare.

Spirifer mucronatus, small form with rounded cardinal extremities associated with a larger and typical form with mucronate extremities: abundant.

Cyrtina Hamiltoniœ, var. *recta.*

Chonetes scitula, abundant.

Athyris spiriferoides, rare

Spirifer audaculus, rare.

Liorhynchus mesacostalis abundant.

This is my northernmost section in the Chenango valley. Prosser (op. cit. p. 224) gives a section at North Norwich, six miles above, from which he reports a very similar assemblage of fossils, with the addition of *Spirifer mesastrialis*, which was not observed at Station A. It may be well to observe here at the outset that this species which is encountered in most of the sections in this region occurs, rarely indeed, but in characteristic specimens in Hamilton shales, whose position beneath the Tully limestone can not be questioned. Before me lies such a specimen from an outcrop three miles east of Borodino, on Otisco lake, Onondaga county. The fauna of Station A, though it evidently is above that of North Norwich so far as here recorded, gives no indication of dissimilarity from a normal Hamilton fauna, either in the association of species, or in the individual peculiarities of the species themselves.

Station B. Quarry on road leading west from Norwich to Preston, running along south bank of Canasawacta creek; one mile west of Norwich post-office, on property of Fred. Titus. Exposure fifteen feet; elevation 150 feet above Station A and 200 feet above the river.

(1) At the base is a light-gray sandstone in three two-foot benches with shaly partings;

(2) Above thin sandy shales, two feet, six inches;

(3) Thick-bedded, highly concretionary sandstone, three feet;

(4) At the top three feet six inches of sandy flags breaking out irregularly.

Layers (2), (3), and (4) are stripped to expose the bottom benches which made a fair quality of sandstone. Fossils are common throughout the shales (2), and highly abundant in the concretions of (3). In the shales large specimens of *Spirifer mesastrialis* occurs sparsely.

Station B_1. At a point about 600 feet further up the road a similar section is better exposed in a quarry owned by John Brookins. Here the exposure is about twenty feet. The concretionary sandstone (3) of above section is here within two or three feet of the top and the lower sandstone (1) is underlaid by four feet of soft bluish shale. The basal stratum is a flagstone whose surface only is exposed.

All the shaly layers are abundantly fossiliferous.

In the lower blue shales observed only at B_1, are

Chonetes scitula in masses.

Tropidoleptus carinatus, abundant and normal.

Spirifer sculptilis.

Cyrtina Hamiltoniæ, normal.

The upper shales of B and B_1, have afforded:

Homalonotus Dekayi.

Bellerophon patulus.

Pleurotomaria sulcomarginata, common.

Paracyclas lirata, abundant.

Grammysia bisulcata, large and typical.

G. magna.

Leda diversa.

Actinopteria zeta. This species of the type of *A. Boydi* abounds and agrees with the original specimen from Ithaca.

Actinopteria Boydi, rare.

Palæoneilo emarginata.

Nucalla corbuliformis.

Modiomorpha mytiloides.

Tropidoleptus carinatus, common.

Chonetes scitula, common.

Atrypa reticularis, a small, finely striated form characteristic of the Hamilton.

Spirifer mucronatus, small form with rounded cardinal extremities.

Spirifer mesastrialis, rare at B.

Some differences are noticeable in the faunas of B and B_1, and A; and by reason of the time and care given to the exploitation of the former, I consider the fauna, as here given, a fuller representation of the actual fossil contents of the strata, than in the case of station A. If, however, there exists a palpable difference between the faunas at B and B_1, and that of the typical upper Hamilton shales in regions where the Tully limestone is present, they may be reduced to the existence in the former of *Actinopteria zeta*, and the not infrequent occurrence of *Spirifer mesastrialis.*

Between stations A and B there are slight exposures along the bed of the creek, and at several points on the side hill. These may be examined with advantage whenever it may prove desirable to trace the continuity of these sections.

Station C. Quarry 250 feet above station B; on estate of Mrs. Randall; leased and worked by G. M. Crandall. Exposure about fifteen feet, as follows; at base:

(1) Compact greenish sandstone breaking out in benches eighteen to twenty-four inches in thickness; four feet contains fragments of fossil wood, one *Psaronius* observed eighteen inches long;

(2) Thin bed of slate pebbles;

(3) Greenish flags alternating with shales, six feet;

(4) Green and gray shales, four feet.

The shales on this section are soft, clayey and greenish. Fossils are exceedingly and remarkably rare throughout. One of the flagstones furnished a thin layer containing *Palæoneilo emarginata*, small form, *Nuculites lirata*, small form, and *Leda diversa.* After long search the soft green shales produced a single specimen of a small *Orthoceras* or *Coleolus.*

Station D. An extensive quarry on the property of Oscar Hale, at top of the hill further west on the same road, and one and one-half miles west of Norwich post-office. Before considering this exposure in detail, a road section may be given, which, though studied at a disadvantage on account of scanty exposures, serves to continue the section given at C almost to the base of section D. The Preston road rapidly rises from the base of the hill below C toward D, and the greenish flags (3) are cut by the road work, above them lying the greenish shales (4) of C. Above these are compact green flags full of shale pebbles and lignites, and weathering very rusty along certain lines. These are about seven feet in thickness. Over these are two feet six inches of greenish flaggy sandstone with black organic vertical markings, above which are two feet six inches of brownish yellow sandstone. At the top of this roadside section are about three feet of soft red and green sandy shales with minute fish bones and entomostracal This top layer can not be far from fifteen feet from the base of the section at D. At D the following exposure is afforded, from the bottom:

(1) Compact light gray-green sandstone, breaking out at the base into flags six to ten inches thick; above these the sandstone

comes out in heavier blocks, but is evidently softer. Twelve feet.

(2) Softish green sandstone passing into six inches to one foot of green shales. Four feet.

(3) Red sandstones, flags, red shales interlaminated with green, full of small irregular concretionary nodules which on weathering give the face of the rock a coarsely cellular appearance. The sandstone is usually soft and frequently discolored with patches of green. Toward the base, between the shale layers it is compact and free of nodules. The colors are brilliant. Six feet.

(4) Red, green and dark clay shales, often soft and weathering into fine, thin fragments. The smooth surfaces of the red shales show rain-drop (?) impressions and the tracks of crustaceans or annelids. Three feet.

(5) Greenish shaly sandstone breaking out into irregular flat pieces. Eight feet.

In the quarry work all these layers are stripped to (1).

Division (2) contains at the top a green sandy stratum with "fucoidal" surface markings, similar in lithological character to fish-bearing strata observed at Greene and Smithville and, without fish-bones, at South Oxford.

No fossils were observed in any of the layers except those referred to in (4) and traces of fossil wood in the basal sandstone. This is our first exposure of the Oneonta sandstones and shales, but without further remark here upon its composition and the almost continuous section we have been able to make from the Hamilton fauna on the Chenango river into these rocks, it is desirable to present the exposure at station E, which caps the section.

Station E. From the top of the quarry at D upward into the woods are scattered exposures which afford approximately the following superposition from the base up:

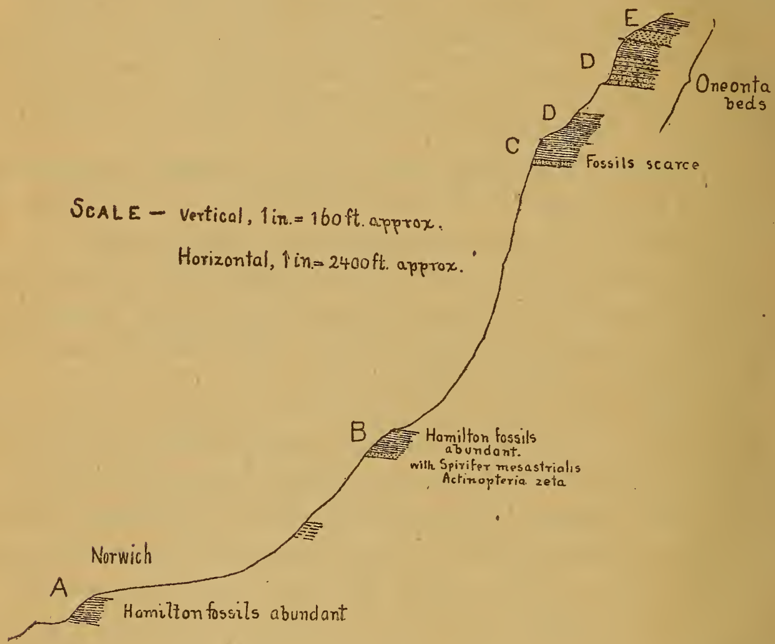
(1) A fawn-colored or light buff sandstone of glittering quartz and feldspar grains with iron dots; even-grained, compact, not schistose at the top, though slaty at the base. Thickness of slaty portion, three feet; of compact portion, three feet six inches. This very peculiar and pretty sandstone is not well exposed at any place, but loosened blocks of it have been hauled off and occasionally made use of in the village of Norwich, as in

the gate posts of the cemetery. The compact portion of the stratum is sometimes curiously cellular in places, the cavities being long and variously branching, as though due to the removal of some concretionary masses.

(2) Green and red sandy shales, six feet.

(3) Compact, thin, fucoidal, greenish flags, two feet six inches. The outcrops of these rocks are mostly on the property of David Evans.

The most noteworthy feature in the composition of these Oneonta beds is, to my mind, the peculiar highly-colored con-



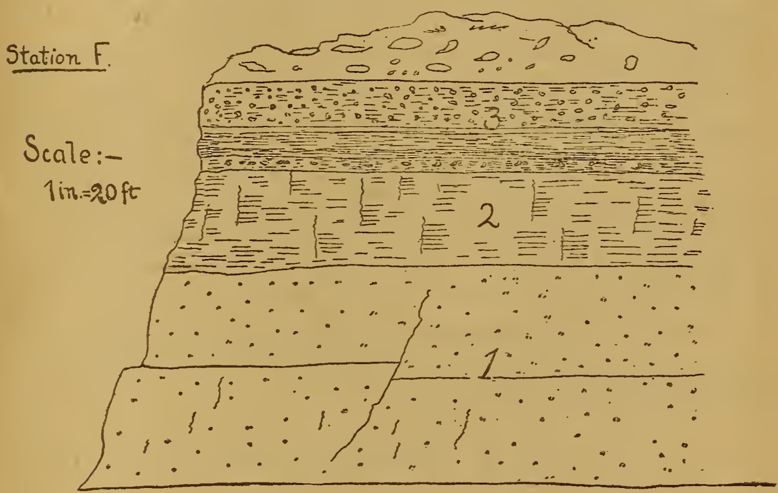
cretionary sands, flags and shales, conspicuously developed at station D (3).

So far as I am aware no one has observed the remarkable similarity in lithological characters of this formation and the so-called "Kramenzel" which abounds throughout the upper Devonian of Germany, especially at the lower horizon of these beds, and which the writer has also observed and described in the lower Portage or Naples beds (a corresponding horizon) in the town of Naples, Ontario county. This is not merely a haphazard resemblance. The "Kramenzel" is a rock composed of small, gnarly, confluent or detached argillaceous concretions usually stained with bright red and green tints. The concretionary goniatite layer of Ontario county unquestionably represents a brief repetition of the physical conditions under which the same fauna existed in Germany. Similarly, the "Kramenzel" of station D must also represent like physical conditions, though barren of organic remains, and the agreement is all the more remarkable, as only in upper Devonian horizons has this highly-colored "Kramenzel" been observed.

In the accompanying sketch is a restoration of the geological succession from station A to E, that is, from near the level of the Chenango river to the summit of the high watershed on the west.

Station F. The F. G. Clark Company quarry, Oxford.

The section here is approximately as follows; at base:



(1) compact, very slightly schistose, even-grained, greenish-gray to bluish sandstone with obscure lamination. This basal layer is the one worked, all the section overlying being stripped. Twenty-five feet.

(2) Irregularly jointed, somewhat shaly sandstone, of greenish tints changing to red toward the top. Ten feet. Mr. Edward E. Davis, of Norwich, N. Y., has recently informed me that he has found specimens of *Amnigenia Catskillensis* in this layer just above the heavy-bedded sandstone.

(3) Green and red compact sandstones, highly concretionary (compare Station D–3). The red soft shales in this mass which

are reddest at the top become porous upon exposure by the removal of the small concretions. Ten feet.

At the south end of the quarry these layers are of a more decided green color, and the concretions are virtually restricted to a thin portion at the top. These upper red and green layers where compact and coming out with clean surface, bear the "fucoidal" markings characterizing certain beds observed at South Oxford, Greene and Smithville to which reference will be made. These surface-markings are branching cavity-fillings composed of sand-grains. The strata bearing them have the same lithological character wherever observed.

No fossils were observed in this section, except Lepidodendra Rhodeas, branching fern stipes, which are abundant in the lower benches of sandstone.

Station G. Quarry on the property of Walker Potter, on the side hill one-quarter mile north of the village of Oxford on the east side of the river. Elevation above river approximately 300 feet. The exposure here consists of five feet of compact greenish sandstone which breaks out as fine thin flags of excellent quality. No stripping is necessary, the top layer of sandstone lying under about four feet of drift, and beautifully marked with glacial striæ running nearly north and south, parallel to the valley at this place.

Following up the hill back of the quarry to the bed of the New York, Ontario and Western railroad, there is, at an elevation of about fifty feet, a small opening into an exceedingly hard quartz sandstone, very light gray or whitish in color, with parallel horizontal rows of minute rusty grain cavities. For the succeeding 100 feet to the railroad these red shales predominate, sandy in some places, soft and clayey in others. The upper bank in the railroad cut shows that these shales are overlaid by a single bench of gray sandstone, two feet six inches thick.

Station H. Quarry on the road from Oxford to Guilford three miles southeast of Oxford, on property of M. L. Walker. The section here gives, at base:

(1) Light, bluish-gray sandstone, strongly water-laminated, and though exposing compact wall-faces, breaking out into thin flags, two to four inches in thickness. These are filled with comminuted plant remains. Seven feet.

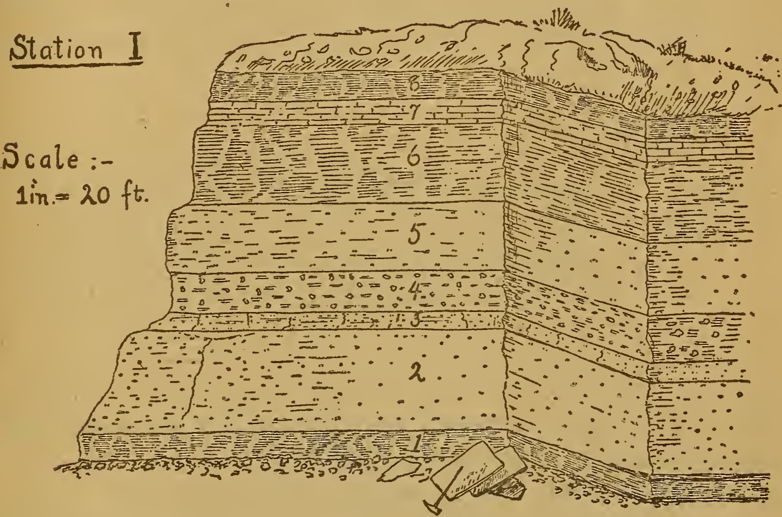
(2) Bright red and green soft shales and sandstones, including a single layer of compact red sandstones which, I am informed,

has furnished much of the red flags seen in the older sidewalks in and about Oxford village. Five feet.

(3) Red shales, some argillaceous and smooth, others sandy and blocky. Two to four feet. No fossils observed.

Among the green layers in (2), just above the basal sandstone, and beneath the red shales, is the characteristic sandy fucoidal layer with fish-scales. The elevation of this point is about 150 feet above the river at Oxford.

Station I. The extensive Miller quarry at South Oxford (Coventry station); The F. G. Clark Co., lessee. Elevation 150 feet above the river.



The section here is the following; at base

(1) Dark blue and greenish clay shales with interlaminated compact, and more shaly beds. Two feet six inches.

(2) Compact, heavy-bedded blue stone breaking out in thick blocks, ten feet. This is the principal layer for which the quarry is worked, the entire overlying section being stripped. The sandstone bears plant remains along certain laminæ, and spots or patches of shale and sandstone breccia containing fish remains.

(3) Blue-stone breaking out too unevenly for use. Two feet.

(4) Greenish concretionary sandy shales alternating with single thin benches of blue stone. Greatest thickness four feet. The greenish layer at the top is "fucoidal," similar lithologically

and in position to the same rock as elsewhere noted. Both green and red layers are highly concretionary, the concretions being small, irregular and confluent; characteristic examples of "Kramenzel."

(5) Gray sandstones presenting thick wall-faces, but coming out as thin flags. Seven feet.

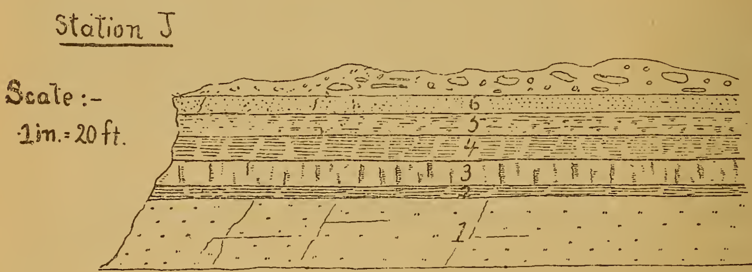
(6) Soft red shales. Eight feet.

(7) Red flags or sandstones. Two feet six inches.

(8) Soft red shales. Three feet.

No fossils, except as already specified, were observed in this section.

Station J. Three miles northeast of Greene and one-half mile north of the river road; quarry on the property of Isaac Edgerton. At base:



(1) Compact, light greenish sandstone, splitting into thin flags at top, but thicker at the bottom; six feet.

(2) Brilliant green and red, soft clay shales; one foot.

(3) Compact red sandstone, schistose on exposure; two and one-fourth feet.

(4) Red shales, slightly sandy; two and one-fourth feet.

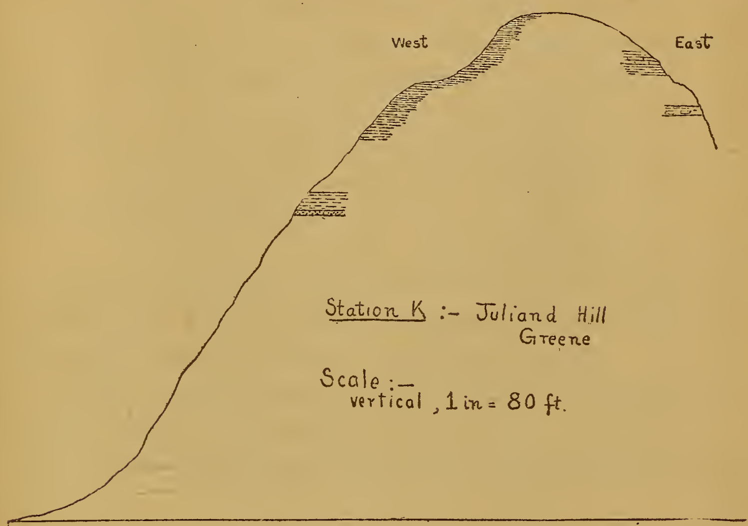
(5) Greenish shaly sandstone with "fucoidal" surface; toward the top this passes into greenish and reddish shales; two feet.

(6) Light gray sandstone; one foot, six inches.

No fossils were observed in any of the layers.

The hill roads south of East Greene (Brisben) afford very few exposures of the strata. It is, however, observable that the upland drift and high level gully-wash contains a very considerable amount of blocks containing Chemung fossils, with fragments of red sandstone.

Section K. Greene; on property of J. A. Juliand, east-south-east of village, one-fourth mile. At about 150 feet above the river is an old quarry opened, as I am informed, some sixty years ago to obtain an eighteen-inch sandstone which here forms the base of the exposure. This is overlaid by thirteen feet of sandy shales containing in places *Atrypa reticularis*, the large and robust form characteristic of the Chemung beds, and *Spirifer mucronatus* var. *posterus*. A short distance further up is another exposure of greenish shales which are softer and more



argillaceous than those below, and these are continued in slight field exposures to the top of the hill, whose summit is approximately 300 feet above the river. Fossils are abundant throughout these shales and are of typical Chemung expression, viz.:

Atrypa reticularis, large, rugose; common.
Orthis impressa, large form; abundant.
Liorhynchus globuliformis, common.
Spirifer mesacostalis.
Productella lachrymosa.
Stropheodonta perplana var. *nervosa.*
Cryptonella sp.

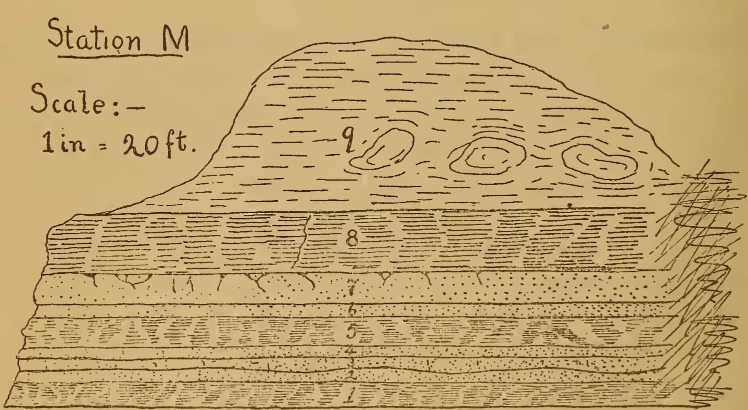
No attempt was made to acquire a full representation of the species occurring here and at the outcrops above. There is apparently little variation in the fauna at the different horizons from here to the summit, though at the summit is a layer containing very abundantly the small finely plicated form of *Atrypa reticularis*. On the east slope of the hill there is an exposure twenty-five feet below the summit, where occurs a calcareous layer largely composed of crinoidal remains; the inclosing shales bear their fossils in thin separated layers, and in places contain very large irregular concretions.

Station L. Cameron quarry in village of Greene, on west side of road leading southwest. At base, three benches of gray sandstone with intercalated shales, overlaid by twelve feet of shaly sandstones. Above this lies a sandstone with large concretions, overlaid by shaly sandstones and thin sandstone benches to top. The entire thickness of the exposure is about fifty feet. Fossils occur as in section K and are abundant in all the shaly strata.

This quarry was opened at the time the canal was put through and has long been abandoned. Vanuxem refers to it in the Third District Report (1842) as one of the characteristic exposures of the Chemung rocks in this county.

The position of the concretionary sandstone here is about 100 feet below the similar stratum observed in Juliand hill, section K.

Station M. Quarry on Birdsall's brook, village of Greene, on road to Smithville, near west line of corporation. Property of Charles Ingersoll. The artificial exposure here is very slight and does not materially aid the natural exposure which is as follows; at base:



(1) Soft greenish sandy shale, rusty on all cleavage faces; no fossils. Two feet, six inches.

(2) Thin greenish-gray sandstone, shaly on weathering, with broadly undulated surface, exposing three folds in bed of stream

having their axes nearly N.— S.; no fossils. One foot, six inches.

(3) Greenish sandstone, mottled with iron stains; generally soft but heavily schistose. Coarse quartz pebbles sparingly scattered through it. Eight inches. Contains *Holonema* cf. *rugosa*, Claypole, undetermined plates, scales and teeth.

(4) Light gray compact sandstone with coarse quartz pebbles at top; no fossils. One foot.

(5) Shaly, light-gray sandstone, with rusty, mud-streaked surface; contains an abundant of lignites. Two feet, six inches.

(6) Same as (3) but more shaly. General effect, dark olive green mottled with brown; "fucoidal" on surface. Fish remains common. Fourteen inches. *Lingula* cf. *Cuyahoga*, *Leptodesma*, cf. *sociale* (single specimen).

(7) Gray sandstone; extending half way across it from top downward are branching worm-borings, which are expanded and funnel-shaped at their openings. These openings give the upper surface of the layer a mottled or pitted appearance.

(8) Compact, sandy greenish flags, even-grained, rectangularly jointed; no fossils. Five feet.

On the roadside above the brook this section is continued and concluded by

(9) Hard, greenish, sandy shales containing large, irregular concretionary masses of sandstone. Fifteen feet.

The elevation of this exposure above the Chenango river is about the same as that of the Cameron quarry, station L.

Station N. About two miles north of Greene on the highway to Smithville Flats are exposed four to six feet of compact greenish, sandy clay-shales containing *Sperifer mucronatus* var. *posterus.* This is a designation given in the Palaeontology of New York, vol. VIII, pt. 2, expl. pl. xxxiv, Figs. 27–31, to a small variety of *S. mucronatus* from the Ithaca beds of Tompkins county. It is there observed: "This shell in one of its forms was identified as *Delthyris mucronata* in Geology of New York, Report on the Fourth District, 1843 (p. 270, Fig. 3), and the shell termed in that work *D. acuminata*, Hall, is probably the same form. It is a variation from the typical form of *S. mucronatus*, similar to those represented in Figs. 15 and 16 of this plate, with broad or narrow bodies and acuminate cardinal extremities.

The original term *acuminata* can not be applied to this shell on account of preoccupancy."

The station also contains:

Gammysia elliptica; rather small form similar to that figured in Pal. N. Y., vol. V, pt. 2, pl. 58, Fig. 1, reported from Ithaca; smaller than the average specimens of the Chemung group.

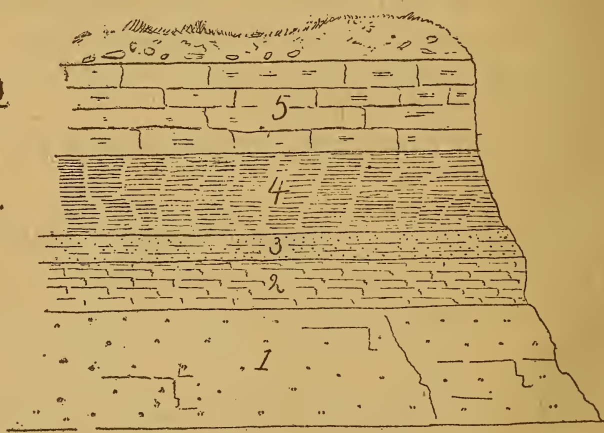
Sphænomya subcuneata. This is a shell of similar character and form, but of persistently smaller size than the average specimens occurring in the Hamilton at Apulia, from Madison county, and in the rocks at New Berlin, Otsego county.

Palaeoneilo, large species, cf. *maxima.*

The elevation of this point is about 200 feet above the preceding. About a half mile north of this outcrop is an exposure of five feet of heavy-bedded sandy shale with crinoid stems and *Spirifer mucronatus* var. *posterus.* No other fossils were observed.

Station O

Scale :—
1 in. = 20 ft.



Station O. Quarry, two and one-half miles north of Smithville Flats, on the property of Miss Sarah Harrison. The exposure here is as follows; at base:

(1) Heavy, light gray sandstone, for which the entire section above was stripped. Twelve feet.

(2) Dark olive green, sandy and compact layers, with "fucoidal" surface markings. Contains fish plates and scales. Four to five feet.

(3) Gray sandstones in three layers; three feet.

(4) Soft, even-grained green clay shale, crumbling on exposure; eight feet. Contains:

Tentaculites, small form, but similar to *T. bellulus.*

Leptodesma Rogersi.

Liopteria, small, suberect form with sharp concentric lines.

Leda diversa, small but typical.

Beyrichia, sp. ?

Orbiculoidea media.

These shales abound in small, spherical or flattened bodies, one millimeter in diameter, covered with a black carbonaceous film, probably spores of lycopodiaceous plants.

(5) Greenish, irregularly schistose sandstones, presenting smooth, compact wall faces. At their base, between it and the shaly stratum (4), is a layer of coarse shale pebbles in which was found *Spirifer mesastrialis*, small form. No other fossil observed; ten feet.

Station P. West bank of Genegantslet creek, four miles northwest of Greene; quarry on land owned by Stephen Davis and Seymour Whitmarsh.

There are exposed twelve feet of heavy-bedded, light gray sandstone, broken and schistose at the top. The stone is of the same quality as that at base of section O.

Station Q. Two miles northwest of Oxford on road to McDonough. Quarry on property of Phœbe Westover, situated on the bank of a small stream, about 200 feet above the Chenango river; exposure, gray, heavy-bedded sandstone, six feet; no fossils.

Also, on highway one-quarter mile east of East McDonough is an exposure of two feet of greenish sandstone, followed below by two feet of red and green shales and red sandstone, resting upon three feet of green flags. No fossils observed.

Also, on highway one-quarter mile west of East McDonough, five feet of soft green clay shales with quartz pebbles, and thin interlaminated sandstone. Compare the shales at station O (4). The only fossil observed was an undetermined *Microdon* or *Palæoneilo.* This locality is about fifty feet above that last mentioned. Between these points and the village of Oxford the red shales and sands abound over the surface, coloring the soil perceptibly though affording no well-defined exposures. Their thickness in this section, including the interlaminated greenish sandstones, I should estimate at about 150 feet.

Station R. On the property of F. E. Corbin, one-half mile south of East McDonough, is an exposure of sandy shales, two feet six inches thick, overlaid by concretionary sandstones, three feet six inches, containing *Microdon gregarius* and *Spirifer mucronatus*, var. *posterus*. Elevation about 600 feet above the Chenango river.

Station S. One and one-half miles south of McDonough, on east side of Genegantslet creek, in a quarry on the property of Ed. Burdick, are exposed:

(1) Heavy bedded, light grey, coarse-grained sandstone with considerable iron cement, breaking out into good flags; twelve feet. No shale or fossils. This quarry lies at the base of a hill on the upper side of the road, and from the top of the quarry to the summit of the hill, a vertical distance of 150 feet, there are exposures of a light gray sandy shale with interlaminated beds of coarse quartz-pebble conglomerate, and capped at the summit of the hill by a heavy bench of sandstone.

These layers above the quarry afforded a few specimens of *Spirifer mesastrialis* which was quite common in the conglomerate, and a small *Liopteria* like *L. Torreyi*.

These are the highest strata met with, as they undoubtedly overlie all sections observed at the south in the vicinity of Smithville Flats and Greene.

Station T. The surface of the country from Norwich to Preston, west of station E, affords few exposures. Here and there red shales and sandstones appear with occasional outcrops of greenish

shaly sandstone. At no point between these villages is the land higher than at station E. From Preston eastward, in the town of Pharsalia the land becomes much higher, and Berry hill, which lies on the eastern boundary of the deep valley, in which the village of East Pharsalia is situated, is one of the highest points in the county, and its summit is about 300 feet above the Genegantslet creek, which is here near its source. Rock exposures are rare.

Station T is an outcrop at the dam on the Genegantslet, in the village of East Pharsalia, affording an exposure of about four feet. At the base is a six-inch schistose sandstone followed above by alternating layers of sandy and clay shales, the former passing into thin masses of coarse quartz conglomerate, the latter being soft, greenish or blackish. At the top of the section is a somewhat concretionary sandstone passing into these flags. All the layers bear fossils except the flags, though they are sparing and isolated. The following species were observed:

In the sandstone:

Rhynchonella congregata, abundant.

Nuculites sp.

Sphenotus sp.

Fish plates.

In the shales:

Lucina? sp.?

Microdon, very small form, cf. *gregarius.*

Grammysia elliptica.

Goniophora subrecta, common.

Plumalina plumularia (*densa?*), common.

Orbiculoidea sp.

Station T_1. West from East Pharsalia there are occasional outcrops up to the summit of the first hill. From the base of the hill upward the rocks have been laid bare only in the process of road-making. At the bottom are greenish sandy shales which must have a thickness of fifty to seventy-five feet. Above these and fully 150 feet above section T is a thin layer of yellowish sandstone, bearing *Tentaculites spiculus* in abundance, with *Rhynchonella congregata* and *Spirifer mesastrialis* common. There is also a large *Spirifer* with the proportions of *S. disjunctus*, but not fully determinable. Green sandy shales overlying this sandstone also contain *Tentaculites spiculus.*

Station T_2. Further westward and at a higher elevation is a ledge of coarse quartz-pebble conglomerate, strongly cross-bedded, ten feet, and above this an even-grained, slightly rusty écru sandstone altogether similar to that observed at the summit of the section at Norwich, station E.

This is the westernmost trace observed on this traverse of rocks related to the Oneonta group. There is little difference in the actual elevation of this écru sandstone in its exposures here and near Norwich. It is, if anything, higher here, and the exposure is also more northerly.

The broad, flat-topped hills lying between East Pharsalia and the valley of the Otselic river do not afford many outcrops, nor does the surface, so far as observed, afford any trace of the characteristic rocks of the Oneonta group. The ravines which cut the high hills in the town of Pitcher and empty into the Otselic river have produced many fine sections.

Station V. Ravine on the farm of George Hakes, one mile north of the village of Pitcher. The section here exposed begins at the base with three feet of sandy shales with bryozoa and crinoidal remains. Similar shaly sandy layers continue the entire length of the ravine and to the top of the hill. At the top as well as at the bottom they contain Hamilton fossils plentifully. The fossil-bearing layers occur at rather wide intervals, the intermediate sandstones and shales being barren. In places the shales are soft and dark, and at times flags are well developed, but always "reedy." The total height of the exposure is fifty to sixty feet.

Fossils:

Liorhynchus mesacostalis in masses in thin, widely separated layers.

Spirifer mesastrialis, abundant.

Sp. small var. of *Tullius.*

Tentaculites bellulus.

Crania cf. *Hamiltoniæ.*

Palaeoneilo emarginata.

Liopteria Sayi, small form.

One mile further north in the ravine formed by Mineral brook, entering the Otselic valley from Pitcher Springs, is another excellent section beginning considerably further down than the preceding and extending quite as far up.

Fossils are rather more abundant here and the following species were observed:

Modiomorpha concentrica.

Microdon bellistriatus.
Rhynchonella congregata.
Spirifer mesastrialis.
S. audaculus.
Chonetes scitula, in masses.
Liorhynchus mesacostalis.

Toward the summit of this section in the vicinity of Pitcher Springs, sandstones and flags predominate, but fossils are found throughout. The total height of the exposure is about eighty-five feet.

At South Otselic, six miles north and about 100 feet higher, is an excellent exposure of the same sandy shales, sparingly fossiliferous. This is seen to best advantage on the plank-road entering the village from the east.

On account of continued rainy weather these exposures in the towns of Pitcher and Otselic were studied at a great disadvantage and extensive collections of fossils were not made.

Station V. Town of Cincinnatus, Cortland county; brook entering the town from the northwest and meeting the Otselic river at Lower Cincinnatus. Geological horizon essentially the same as at Pitcher, the less elevation at Cincinnatus being compensated by the dip of the strata. The section affords at the base:

(1) Soft, bluish to greenish clay shales; fossils rare, single specimen of *Liopteria* sp. only observed. Six feet.

(2) Sandy shales with flags. Forty feet.

(3) Heavy sandstones.

In (2) and (3) fossils are not uncommon, and those observed are mentioned in the following list:

Phacops rana, rare.
Spirifer mesastrialis, large and characteristic; abundant.
Sp. audaculus, small; rare.
Sp. mucronatus, a short-winged, highly lamellose form, resembling *S. sculptilis.*
Rhynchonella congregata, abundant.
Cyrtina Hamiltoniæ.
Ambocœlia umbonata, rare.
Liorhynchus mesacostalis, abundant.
Cryptonella sp.

Atrypa reticularis, finely striated form.

Orthoceras sp. ?

Tentaculites bellulus, common.

T. sp. undes.; almost without annulations, very fine concentric striæ.

Hyolithes sp.?

Liopteria DeKayi, large, normal form; abundant.

Microdon gregarius (or *bellistriatus*); abounds on thin slabs.

Actinopteria eta, rare.

A. perstrialis, rare.

Schizodus appressus, more orbicular than usual.

Modiella pygmæa, rare.

Palæoneilo brevis.

Sphenotus contractus.

Grammysia elliptica, common.

Scales of *Holoptychius* or *Bothriolepis.*

Resume.

The description of a number of sections, for the most part isolated, leaves the mind somewhat beclouded as to their interrelations. To return then to the point of departure, the first series of sections here described, beginning at the Chenango river at Norwich and rising to the summit of the high hill at the west, shows very clearly that the Oneonta sandstones, red and green shales are underlaid by sandy shales, flags and sandstones, the last two predominating, and fossils becoming exceedingly sparse toward the top, the more shaly portions beneath being frequently highly fossiliferous. Do these fossiliferous sandy shales bearing predominant Hamilton species, some of them slightly modified in form from their usual appearance in the Hamilton fauna, but associated with *Spirifer mesastrialis* and *Actinopteria zeta*, *eta* and *perstrialis*; does this *mesastrialis-fauna* lie above the horizon of the Genesee shales? This is the critical question, the answer to which must determine the geological position and equivalence of the Oneonta sands and shales.

The easternmost recorded exposure of the Genesee shales in New York is near Smyrna, a village on the west side of the Chenango valley about twelve miles north of Norwich. Closer to the river the formation seems to have disappeared entirely, and hence its absence leaves a certain element of doubt as to the position of the *mesastrialis*-fauna, though there is no evidence either in the physical structure of the valley or in the observed succession of the rocks at Norwich for assuming that these Genesee shales or their horizon is to be found in the section somewhere between its base and the appearance of the red shales and sandstones. In the western towns of Chenango county and in Cincinnatus the evidence on this point is more direct. In Cincinnatus, Pitcher and Otselic the *mesastrialis*-fauna is well developed and of quite the same character as that of the lower beds at Norwich. But these beds clearly and unmistakably lie above the Genesee shales, which were observed by me in several places, *en passant* just north of the village of Lincklaen on the road to De Ruyter. On Prof. S. G. Williams' map showing the extent of the Tully limestone in New York (Sixth Annual Report State Geologist, 1887) this formation is represented as passing close to, slightly to the north and east of the village of De Ruyter. There is hence positively no question that the Cincinnatus and Pitcher beds containing the *mesastrialis*-fauna lie above and probably immediately above the Genesee shales. And with as little hesitation we may infer that the Norwich representation of the same fauna lies above the horizon of the Genesee shales. Throughout the western part of the region here under consideration the upper portion of the series was not closely studied. It was, however, observed that in the section between Pitcher Springs and the Otselic valley, sandstones and thick flags gradually become predominant in the upper layers; this is very clearly shown in the Chenango valley sections, where the increase in the arenaceous character of the sediment is accompanied by a diminution of organic life.

All this, however, is no new determination. Vanuxem in his special chapters (Report Third Geological District, 1842) on Chenango and Cortland counties referred these rocks to his Ithaca group, without any detailed observations in regard to superposition or the character of the successive faunas. As the Hamilton fauna was elaborated and its component species became fairly well known, it is quite natural that the rocks bearing these supra-Hamilton faunas in the Chenango valley and Otsego county should have been, in a desultory fashion, referred to the Hamilton group. The predominant traits of the fauna are Hamilton; its extra-Hamilton species are rare, especially in the lower parts of the series. Where the Tully limestone and Genesee shales are present, it is at the outset simply a recurrent Hamilton fauna, gradually becoming modified by the disappearance of some of the more pronounced Hamilton types, especially the gastropods, slight modifications in others that remain and the introduction of new specific types.

Where the capstones (Tully and Genesee) of the normal Hamilton are wanting, as in and eastward of the Chenango valley, such a recurrence is not possible. The Hamilton fauna has perpetuated itself without interruption, and it is, therefore, in one sense logically and correctly a Hamilton fauna. Should it prove possible to establish the horizon of these absent formations in this eastward region there might be found therein a basis of division in the succession. But notwithstanding the continuity with modification of the Hamilton fauna in the Chenango valley and eastward the intervention of the Tully and Genesee formations westward, *makes* the division, which must also be recognized in the eastward region; probably here the best index of the change will prove to be the appearance of *Spirifer mesastrialis*, which, as already observed, Prosser has recorded from a locality at North Norwich several miles above my northernmost record in the Chenango valley.

These Ithaca beds, then, occupy the place of the Portage group, as the immediate successors of the normal Hamilton series of central and western New York. In the same sense the *mesastrialis*-fauna and the peculiar Goniatite fauna of the typical Portage are syntactic in the time-scale; but to speak of either these Ithaca beds or the *mesastrialis* fauna as "Portage" or "belonging to the Portage stage,"* seems to me misleading, if admissible.

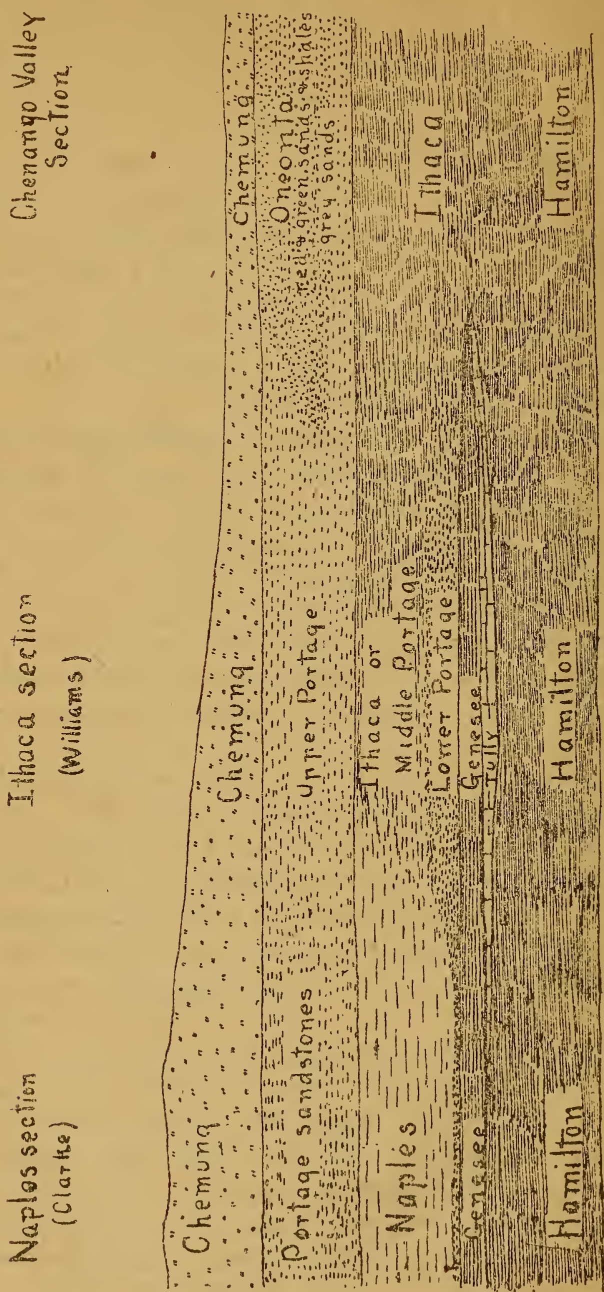
There are certain lithological differences in the Ithaca beds of Cortland, Chenango and Otsego counties and the typical Portage beds of Genesee, Livingston and Ontario counties. Between the Portage fauna and the Ithaca fauna there is nothing in common. Two syntactic faunas could hardly be more fundamentally different. We speak now of the *typical* Portage fauna; not that of Ithaca, but that of the Genesee section or its

* See Prosser op. cit. p. 230.

more favorable as well as more carefully studied development in Livingston and Ontario counties. To the two at their fullest development, the one in these last mentioned counties, the other in the Chenango valley region and eastward, there is, so far as known, no single species common. The *mesastrialis*-fauna is richly brachiopodous, its cephalopod element meager and orthoceran; the normal Portage fauna is almost devoid of brachiopods, its prevailing element is cephalopodous (*Goniatites*, *Clymenia*, *Bactrites*). Though lamellibranchs abound in both, the Actinopterias, Grammysias, Palæoneilos, Microdons of the former are in contrast to the Lunulicardiums, Buchias, Cardiolas and "Lucinas" (a name which covers a number of undetermined palæoconchs) of the latter. The passage from one into the other is indicated in the Cayuga lake section.

The comparatively barren shales and sands which immediately overlie the Genesee in the Ithaca section are but slightly represented in the Naples and Genesee valleys. I have no evidence to offer as to their presence in Chenango and Cortland counties. The fossiliferous zone bearing the Ithaca fauna in Tompkins county is, according to Williams, restricted to that part of the series overlying the basal sandstones. In the western, middle and eastern sections, the fossiliferous zone, whatever the differences in its organic contents, is overlaid by heavy-bedded, very sparsely fossiliferous sands which are probably continuous or synchronous and which, in their western development, constitute the original "Portage sandstones," of Prof. Hall. The Ithaca fauna, like that of the Oriskany and Lower Helderberg, is one having its best and normal development in New York, toward the east. The Naples fauna has its normal development in the western counties. Each is peculiar in its composition and distinct from the other, and to embrace both under one term is to perpetuate an error. The organic connection between the Ithaca and Hamilton faunas is far more intimate than between the Naples and Hamilton faunas, for the simple reason that where the Tully and Genesee beds do not separate the two because of their absence, there the Ithaca fauna attains a high development. The Naples fauna, on the other hand, reproduces some of the peculiar features of that of the Genesee, with which it is naturally more closely allied from close contiguity and immediate succession than with the remoter fauna of the Hamilton beneath.

The accompanying sketch will roughly indicate the conception here expressed of the relations of the eastern and western faunas.



To return to the Chenango valley and its Oneonta beds; it has been shown that these red and green shales and sandstones overlie the barren sandstones capping the fossiliferous Ithaca beds. Mention has been made of the extensive development in these Oneonta beds of the peculiar layers of red and green concretionary masses, the typical "Kramenzel," which also occurs on a much smaller scale in the Naples beds of Ontario county. This concurrence of a lithological character in the upper Devonian, which is so unusual in this country, and so widespread and characteristic at corresponding horizons throughout Germany, especially in the Eifel and Westphalia, can not be a mere incident. The evidence before us seems to me to indicate that these Oneonta beds (including the barren gray sands and flags lying beneath the red and green shales and sands) are the eastern representative of the upper sandstones and flags originally designated by Prof. Hall as the "Portage sandstones," and are hence the sedimentary equivalent of the typical Portage. The sections in the vicinity of Greene show very clearly that these beds are overlaid by a typical and highly-developed Chemung fauna.

Respectfully yours.

JOHN M. CLARKE.

A LIST OF PUBLICATIONS

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1876-1893.

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1876.

S. T. BARRETT.—Notes on the Lower Helderberg Rocks, with Description of a new Pteropod.

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(Pop. Sci. Mo., vol. 8, pp. 357–363.)

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(32d Ann. Rept. N. Y. State Mus. Nat. Hist., pp. 141–176.)

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(Amer. Jour. Science, vol. 19, pp. 225, 226.)

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(Utica, N. Y., pp. 1–20.)

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(Amer. Naturalist, September, pp. 793–801.)

J. M. Clarke.— The Protoconch of Orthoceras.
(Amer. Geologist, vol. 12, pp. 112–115.)

C. F. Cox.— On recently discovered deposits of diatomaceous earth in the Adirondacks.
(Trans. N. Y. Acad. Sci., vol. 12, pp. 219, 220.)

N. H. Darton.— Stratigraphic relations of the Oneonta and Chemung formations in eastern central New York.
(Amer. Jour. Science, vol. 45, pp. 203–209.)

N. H. Darton.— On Two Overthrusts in eastern New York.
(Bull. Geol. Soc. Amer., vol. 4, pp. 436–439.)

Arthur S. Eakle.— On some Dikes occurring near Lyon Mt., Clinton Co., N. Y.

(Amer. Geologist, vol. 12, pp. 31–36, pl. 2.)

James Hall, assisted by J. M. Clarke.— Palæontology of New York, vol. VIII, part 2, fascicle 1, pp. 1–276.

James Hall, assisted by J. M. Clarke.— Palæontology of New York, vol. VIII, part 2, fascicle 2, pp. 177–317.

Arthur Hollick.— Additions to the Palæobotany of the Cretaceous formation on Staten Island.

(Trans. N. Y. Acad. Sci., vol. 12, pp. 28–40, pls. i–iv.)

Arthur Hollick.— Preliminary Contribution to our Knowledge of the Cretaceous formation of Long Island and eastward.

(Trans. N. Y. Acad. Sci., vol. 12, pp. 222–237, pls. v–vii.)

A. A. Julien.— A Study of the New York Obelisk as a decayed boulder.

(Ann. N. Y. Acad. Sci., vol. 8, pp. 93–166.)

J. F. Kemp.— A review of the work hitherto done on the Geology of the Adirondacks.

(Trans. N. Y. Acad. Sci., vol. 12, pp. 19–24.)

J. F. Kemp and V. F. Marsters.— The Trap dikes of the Lake Champlain region.

(Bull. U. S. Geol. Surv., no. 107, pp. 1–62, pls. i–iv.)

W. D. Matthew.— Antennæ and other appendages of Triarthrus Becki.

(Amer. Jour. Science, vol. 46, pp. 121–125, pl. i.)

W. D. Matthew.— On Antennæ and other appendages of Triarthrus Becki.

(Trans. N. Y. Acad. Sci., vol. 12, pp. 237–241, pl. viii.)

F. L. Nason.— Notes on some of the Iron-bearing rocks of the Adirondack Mountains.

(Amer. Geologist, vol. 12, pp. 25–31.)

C. S. Prosser.— The Thickness of the Devonian and Silurian Rocks of central New York.

(Bull. Geol. Soc. Amer., vol. 4, pp. 91–118.)

Heinrich Ries.— Notes on the Clays of New York State and their economic value.

(Trans. N. Y. Acad. Sci., vol. 12, pp. 40–47.)

C. H. Smyth, Jr.— Lake-filling in the Adirondack Region.
(Amer. Geologist, vol. 11, pp. 85–91.)

C. H. Smyth, Jr.— A geological reconnaissance in the vicinity of Gouverneur, N. Y.
(Trans. N. Y. Acad. Sci., vol. 12, pp. 97–108.)

C. H. Smyth, Jr.— Petrography of the Gneisses of the town of Gouverneur, N. Y.
(Trans. N. Y. Acad. Sci., vol. 12, pp. 203–217.)

J. J. Stevenson.— Use of the name "Catskill."
(Amer. Jour. Science, vol. 46, pp. 330–336.)

Warren Upham.— Eskers near Rochester, N. Y.
(Proc. Rochester Acad. Sci., vol. 2, pp. 181–200.)

H. S. Williams.— Ventral plates of the Carapace of the genus Holonema of Newberry.
(Amer. Jour. Science, vol. 46, pp. 285–287.)

Total publications, 1876–1893, 450.

ADDENDA.

1880.

W. B. Dwight.— Recent Palæontological Investigations in the vicinity of Poughkeepsie.
(Proc. Poughkeepsie Soc. Nat. Science, vol. 31, pp. 15-20.)

1882.

W. B. Dwight.— Recent Investigations and Palæontological Discoveries in the Wappinger Valley limestones of Dutchess and neighboring counties, New York State.
(Proc. Amer. Assoc. Adv. Sci., vol. 31, pp. 384–387.)

1884.

W. B. Dwight.— An interesting geological locality at Cornwall, Orange county, N. Y.
(Trans. Vassar Brothers' Institute, vol. 2, pp. 74–83.)

W. B. Dwight.— Report of Progress in Geological Investigation in the vicinity of Poughkeepsie.
(Trans. Vassar Brothers' Institute, vol. 2, pp. 141–152.)

W. B. Dwight.— Recent Investigations and Palæontological Discoveries in the Wappinger limestones of Dutchess and neighboring counties of New York State.

(Naturalist's Leisure Hour and Monthly Bull. No. 81, May, pp. 4–9.)

1885.

W. B. Dwight.— Discovery of fossiliferous Potsdam Strata at Poughkeepsie, N. Y.

(Proc. Amer. Assoc. Adv. Sci., vol. 34, pp. 204–209.)

W. B. Dwight.— The peculiar structure of Clark's clay-beds (near Newburgh, N. Y.).

(Trans. Vassar Brothers' Institute, vol. 3, pp. 86–97.)

1887.

W. B. Dwight.— Primordial Rocks of the Wappinger Valley limestones.

(Trans. Vassar Brothers' Institute, vol. 4, pp. 130–141, map.)

1890.

W. B. Dwight.— Discovery of a Trenton limestone rich in Ostracoid Entomostraca, and other fossils, at Pleasant Valley (Dutchess county), N. Y.

(Trans. Vassar Brothers' Institute, vol. 5, pp. 75–77.)

W. B. Dwight.— Discovery of Fossiliferous Strata of the Middle Cambrian at Stissing, N. Y.

(Trans. Vassar Brothers' Institute, vol. 5, pp. 102–109.)

GEOLOGICAL SURVEY OF THE STATE OF NEW YORK

DEPARTMENT OF PALÆONTOLOGY.

PALÆONTOLOGY.

ALBANY, N. Y., *February* 24, 1894.

The work on the Palæontology has progressed as rapidly as practicable. Volume VIII, part 2, is very nearly completed; the text is printed up to about 320 pages, and the matter already in type will bring it to about 350 pages. Only six plates remain to be lithographed, and the printing of the lithographic stones up to 1,000 copies each, has been nearly completed, with the exception of the last four stones. In order to complete the edition there remain yet to be printed 2,000 copies each of about twelve or fifteen stones. The work remains unfinished for the want of sufficient appropriation to carry it forward to completion.

In order to secure date of publication I have had fifty copies of the text of the volume bound and distributed, the work appearing in two separate parts, or fascicles. The first of these was published in July, 1893; the second fascicle, carrying the work up to 317 pages, was issued in December, 1893, and copies distributed to scientific workers and to scientific societies. It is a great misfortune that the volume in its entire condition was not issued before the end of 1893 as it could easily have been, had the means of publication been available. The delay in the publication of volume VIII, part 1, and of part 2 is not in any manner due to the author or to any one connected with the work, but simply because of the failure of the supervision to provide the means for its publication.

The work upon the fossil sponges has progressed rapidly since last year, when the Legislature made an appropriation providing means to carry on the work toward completion. Owing to this action on the part of the Legislature work has been resumed upon these fossils, and the original drawings are now nearly all completed for forty six-plates of imperial quarto size. The manuscript for the text is far advanced and will be completed before the end of the year, and the memoir will be communicated to the Legislature at the next session, with the report of the State Geologist.

The only remaining work of great importance and which has not been advanced, is that of the fossil corals which remains in the same condition as heretofore presented ; there being drawings already prepared for nearly 100 ordinary quarto plates. Thus far no provision has been made for any publication upon this class of fossils. The illustrations already prepared, at a very considerable labor and cost, are not available for any educational or other useful purposes, unless brought before the public in some form, and will otherwise be entirely lost to science. The material already illustrated and the large collections remaining in the museum will furnish the means of a more complete illustration of palæozoic corals than has yet been published in any country. While there is no necessity for the immediate outlay of any large sums of money for this object, I would earnestly recommend the annual appropriation of a small amount, in order that the work may progress toward the final publication of a memoir upon the "*Fossils Corals of the State of New York.*"

There is also in progress the work upon the illustration of the handbook of Brachiopoda, the first part of which has been published in the report of the State Geologist for 1891 (1893.) This first part of the handbook contains 223 pages of text illustrated by 286 figures ; a map of the world showing the geographic distribution of the living Brachiopoda ; and twenty-two lithographic plates containing 470 figures which illustrate the external form and internal structure of ninety-eight genera of this class of fossils.

The second part of this handbook which is communicated with the present report will contain thirty-two lithographic plates with accompanying text and illustrations. The work will also contain a resumé of the results coming from the studies of the Brachiopoda which have been carried on for many years, together with a proposed classification of this class of fossils, based upon these results.

A memoir upon the Palæozoic Bryozoa, containing twenty-four plates, which has been in progress of preparation for several years, and remains unpublished for want of means to furnish the proper illustrations, will be communicated with the next eport of the State Geologist.

PALÆONTOLOGY OF NEW YORK.

VOLUME VIII, PART II.

Synopsis of Contents.

Of this volume, entitled "An Introduction to the Study of the Genera of the Palæozoic Brachiopoda," Part I was issued in 1892, and some account of its contents was given in the report for that year. Part II has not yet been issued in its completed form. On account of interruption in the printing of the lithographic plates, it became evident early in the year that the publication of this second volume would be seriously delayed, if the text were to be held back until the plates were completed. As the printing of the text was progressing as rapidly as consonant with the character of the work, it was deemed advisable to issue it in the form of fascicles whenever the completion of any large group of generic discussions justified it. Accordingly, in July, 1893, Part II, Fascicle I was issued and distributed to scientific societies and workers in Palæontology. This fascicle covered pages 1–176, with 155 cuts, and embraced all palæozoic genera of the spire-bearing brachiopods. Following is the table of its contents, in which the generic names in italics are those here regarded as irretrievable synonyms.

II. Brachiopoda Articulata — (*Continued*).

Fascicle II was issued in December, 1893, and was distributed to those persons and institutions which had received Fascicle I. This part completes the generic discussions, covering pp. 177–317, and text illustrations 156–251. Its contents are as follows:

The printing of a concluding chapter treating of the interrelations and classification of the genera is completed and the pages are already in type. The explanations of the lithographic plates have been printed off to plate lxi inclusive. The remainder of this matter, together with the index, is ready for the printer, except for plates lxxxi–lxxxiv.

Of the plates of Part II of this volume there will be 64 numbered from xxi to lxxxiv inclusive. These are all drawn on stone with the exception of lxxxi, lxxxii (in hand), lxxxiii, lxxxiv. The printing of these plates has latterly gone forward rapidly, and proofs of all finished stones have been delivered at this date.

February 12, 1894.

POSTSCRIPT.

November, 1894.

As stated in my annual report under date of February 24, 1894, the printing of the Palæontology of New York, volume VIII, part 2, was discontinued in December, 1893, on account of the exhaustion of the appropriation.

To meet the requirements of completing and binding one thousand copies of this volume, for which the manuscript was already prepared, the necessary sum was asked from the finance committees of both houses of the Legislature of 1894, and was favorably reported by them in the supply bill. While this bill was under consideration in conference committee of the two houses, through some "malign influence," the item making this appropriation was so modified as to render the amount payable from the general appropriation for salaries and expenses of the department of Geology and Palæontology. In this form the item passed the Legislature and went to the Governor. Among the few items in the supply bill which were vetoed by the Executive, this called for his especial disapproval, as its object seemed to be to embarrass and obstruct the scientific work of this department.* In view of these facts, I deem it imperative to insert in this report the essential portion of this unpublished part of volume VIII, namely the final chapter or summary upon the classification of the genera of the Brachiopoda. This will include also the descriptions of the new species which have been studied during the progress of printing this volume.

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* "After this item of appropriation passed each branch of the Legislature, and while the bill was pending in conference committee, there was inserted a provision making the appropriation payable out of the annual appropriation for the services and expenses of the State Geologist for the next fiscal year. This qualification can have no other purpose except to embarrass the State Geologist. With equal propriety could the Legislature provide that the expenses of the Legislature should be taken out of the salaries of Assemblymen and Senators. Such a qualification is wrong in principle and requires the disapproval of the appropriation."

[Extract from Palæontology of New York, Vol. VIII, Part 2.]

The Evolution of the Genera of the Palæozoic Brachiopoda.

SUMMARY.

At the conclusion of the discussions upon the Inarticulate palæozoic genera, some inferences were drawn as to the phylogeny and derivation of the more conspicuous types of inarticulate structure (Part I, pp. 161–170). At that time it had become evident that the variation in the form, position and mode of enclosure of the pedicle-passage affords, a more satisfactory index of lines of progress and development, and gives a more lucid and reliable conception of the rise and decline of brachiopod genera, than the modifications in any other single character or association of characters.

Previous writers have usually ascribed a high value to the disposition of the muscular scars upon the inner surface of the valves, the form of the genito-vascular sinuses, the configuration and degree of calcification of the brachia. The last of these must still be regarded as having a significance inferior in importance only to the mode of enclosure of the pedicle; but to the other features mentioned our present knowledge accords a less value in classification. By this is meant that the muscular system, the disposition and interrelations of the separate muscular bands, adheres closely to a standard type of expression throughout the Class.

This is especially true of the Articulate genera, where, from beginning to end, no radical modification of the type, in this respect, is effected. It is less true, perhaps, in the more highly specialized and more complicated muscular structures of the Inarticulates, a group in which our knowledge of the fossil representatives is not altogether satisfactory on account of the tenuity

and ready destructibility of the shells. It is quite natural to find in such a highly organized group the possibility of variation more frequently manifested.

The opinion expressed in the "Conclusion" to the Brachiopoda Inarticulata, that the "feature of paramount importance" in dealing with the evolution of the palæozoic brachiopodous genera "will be found in the character of the pedicle-passage" (p. 161),* its conformation and accessories, has been substantiated by all the later investigations of this work and is still maintained as the true basis of classification.†

It is not the present purpose to recapitulate at any length the substance of the deductions already set forth in regard to the Inarticulate genera. The views expressed have not been materially modified; but during the interval since their publication an extraordinary interest has been manifested in the study of the Brachiopoda both recent and fossil, especially in France, Austria and America, and the additions thereby made to our knowledge invite special attention.

Lingula has been shown to be a comprehensive type, not existent in primordial faunas. As yet we are unable to indicate any difference of generic importance between the Lingula of the Lower Silurian and that of existing seas. Its elongate form is not primitive, and its complicated muscular system is indicative of an advanced stage of progress. We may therefore look for the precursors of this type of structure among the less elongate (Lingulella) and more orbicular genera (Ob· lus Obolella). In the diagrammatic scheme of the derivation of Lingula, given upon page 164 of Part I, Lingulella and Obolella are represented as divergent from some unknown earlier inceptive stock, whose existence, represented by a mark of interrogation, was deemed probable from the comparative study of these genera.

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* It is proper to explain in this place, that though the title-page to Vol. III, Part I, bears the date of 1892, the pages relating to the Inarticulata, including the concluding chapter referred to, had been completed and printed in July, 1890. Certain of these (pp. 120–160), relating to the structure and development of the pedicle-passage in Orbiculoidea, Schizocrania, Trematis, etc., were reset and issued separately at that date, with lithographic plates (IV e and IV f), and this printed excerpt was distributed among students of the Brachiopoda as well as to the general scientific public.

† The subordinal classification of the Brachiopoda introduced by Waagen (1883–1885) was based to some extent upon the conformation of the pedicle-passage. The phyletic value of variations in this structure was first clearly indicated by Eugene Deslongchamps, and has been subsequently elaborated by several writers.

Such an inceptive form would presumptively be wholly elementary in its contour, outline and structure of pedicle-opening, and, in fact, be little more than an amplification of the infantile condition in its descendants. It has since been observed by BEECHER that the embryonic shell or protoconch (*protegulum*) of the brachiopod is "semicircular or semielliptical in outline, with a straight or arcuate hinge-line, and no hinge-area. A slight posterior gaping is produced by the pedicle-valve being usually more convex than the brachial."* It appears, furthermore, to be composed of corneous, impunctate shell-tissue. The same investigator finds that the species described by BILLINGS as *Obolus Labradoricus*, from a horizon at L'Anse au Loup, now regarded as Lower Cambrian, and subsequently identified by WALCOTT, at the same horizon at Swanton, Vermont,† is the nearest approach of the adult brachiopod to the simple type of the protoconch; a semicircular corneous shell, with gaping cardinal margins. This shell has been distinguished by the generic term PATERINA.

There are, undoubtedly, other brachiopodous shells of obolelloid type that are quite as ancient as PATERINA; still the latter exemplifies the line along which the development of more complicated forms has proceeded, and it is in all respects the simplest known brachiopod. PATERINA is an embodiment of the predicted ancestor of the linguloids and obolelloids, and, with our present knowledge, it appears to be the radicle of all the Brachiopoda, both inarticulate and articulate.

The departure from LINGULA, through LINGULOPS and LINGULASMA to TRIMERELLA, by the progressive development of the

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*BEECHER; Development of the Brachiopoda, Part I, Introduction; American Journal of Science, vol. XLI, p. 344. 1891.

†In a later work Mr. WALCOTT has concluded that the Swanton fossil is sufficiently distinct from the typical *Obolus* (or *Kutorgina*) *Labradoricus* to require a new designation, and has therefore termed it *Kutorgina Labradorica*, var. *Swantonensis* (See "Fauna of the Lower Cambrian;" Tenth Ann. Rept. Director U. S. Geological Survey, pl. lxiv, figs. 2, 3, dated 1890, issued 1892). The figures given in the work cited show that the var. *Swantonensis* is in many respects the more primitive type, its valves being the more nearly equiconvex, its surface characters simple concentric striæ, while in the typical *O. Labradoricus*, there is a conspicuous elevation of the umbo of the pedicle-valve, a low median sinus on the brachial valve, as well as indications of radial plications about the beak; all these are secondary characters which indicate progress toward the true KUTORGINA (*K. cingulata*). It seems evident that the generic term PATERINA was based upon the Swanton fossil, and hence, if the author's intentions are correctly interpreted, the type of the genus is *Paterina Swantonensis*, Walcott. As to the value to be ascribed to differences of shell-composition within a given association of closely related genera, see remarks under the discussion of LINGULA and TRIMERELLA and in the following pages.

vaulted muscular platform (see Part 1, pp. 46, 165) is confirmed by evidence which is unusually complete and conclusive. Various intermediate stages have also been indicated by which a similar resultant is attained from the primitive obolelloids through Lakhmina, Elkania and Dinobolus (p. 28, plate iii, iv*b*). The chronogeny of the various elements is in full accord with the structural progress along both lines of derivation; a single genus in this series, Lingulops, enduring in an unmodified condition from faunas (Hudson river) antedating the appearance of Trimerella, to those in which Trimerella abounds (Niagara and Guelph dolomites).

The entire group of linguloid and oboloid genera is bound together, as already shown, by the possession of an uninclosed marginal pedicle. They compose the Mesocaulia or Lingulacea of Waagen (1883) (Atremata of Beecher, 1891).*

The leading element in this group, Lingula, attained a static condition in early Silurian faunas; the oscillations of the type were mainly confined to the preceding faunas; those of later date are but slight departures in a few directions only. The combination termed Lingula having once become fixed, maintained itself with unexampled adjustment to changing conditions, even into the existing seas. Glossina, Dignomia, Barroisella and Tomasina, which represent early deviations along the line of its descent, embody no substantial variations, though the two last named demonstrate the gradual assumption of articulating processes, a tendency which not infrequently makes itself apparent in this group where the pedicle-passage is wholly marginal. It is seen in Spondylobolus, is sometimes faintly manifested in Obolus and Obolella; in Trimerella there is occasionally a low cardinal process, as shown by Davidson and King, and Gotland specimens of *T. Lindstrœmi* bear long submarginal slotted ridges

*To insure greater freedom of treatment and relief from the embarrassments of an inelastic classification, the discussions in these volumes have intentionally been left free of terms designating taxonomic values higher than genera. By provisionally declining allegiance to any prescribed formulas in classification, not only has the manner of treatment of the comprehensive material studied been more natural, but the student will find him elf less encumbered with artificial restrictions and freer from collisions with rock-ribbed party-walls, which, to use an old Scotch phrase, "are nane o' God's makin'." It had, nevertheless, been the intention to summarize, in a tabulated form, at the close of this work, the broader relations of the genera discussed, not with any intention of introducing a series of new taxonomic terms, but to express succinctly these interrelations as they appear upon a review of the whole field of research. Such a table will be found at the close of this chapter.

on the cardinal edges (Lindström). This mode of articulation though not frequently seen in American specimens of Trimerella, is so much like that of Eichwaldia, and the general form of the shells of the two genera is so similar that there is a good excuse for associating them closely, as has been done by Œhlert, who places the latter genus among the Inarticulates. Eichwaldia presents a peculiar modification of the pedicle-passage, and all its essential characters acquired at an early Silurian age were maintained to the close of the Upper Silurian without substantial variation. The origin of Eichwaldia is, at present, but a matter of conjecture; such resemblance as it bears to Trimerella, in its incipient articulating apparatus, seems to be only an instance of isomorphy.

The second main division of the Inarticulate genera is composed of those in which the pedicle-aperture, in the immature stages or in primitive adult conditions, takes the form of a marginal incision of the pedicle-valve, but becomes inclosed in the shell-substance in later stages of growth. To this group Waagen applied the term Diacaulia* (or Discinacea, 1883), which, like Mesocaulia, is an admirable expression of the significance of the pedicle-passage. The name Neotremata was subsequently introduced by Beecher (1891) as an ordinal term for not only such forms as these, but also for those like Crania of whose fixation by means of a pedicle there is yet no evidence.

The mode of development and enclosure of the marginal incision in the genus Orbiculoidea has already been demonstrated,† and it has been shown that Œhlertella, Trematis and Schizocrania which have an unenclosed aperture at maturity, are primitive conditions through which Orbiculoidea passes in the development of the individual. These primitive adult conditions occur in various faunas from the primordial (Discinolepis) to the Lower Carboniferous (Œhlertella), and while these genera

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* This name was originally printed Daikaulia, probably a typographical error in the spelling of the first syllables.

Waagen, following usage in the employment of the terms Lyopomata and Arthropomata, as ordinal designations, subordinate only to the name of the Class, Brachiopoda, introduce Mesocaulia and Diacaulia as names of *Suborders*. It is a purely arbitrary matter whether the former terms be regarded as designations of orders or subclasses. They are, in either case, inferior in the first degree to the Class itself. Hence the fact that Waagen employed the latter terms as suborders is no ground for rejecting either of them for a later name, but having the same breadth of meaning.

† Volume VIII, Part I, *loc. cit.*

might be conveniently associated on the basis of this feature, it is doubtful whether such grouping would be a natural one, or a proper expression of the relations of these forms to the various contemporary mature types.

In Acrotreta, Conotreta, Linnarssonia, Acrothele and Iphidea the pedicle aperture is persistently located at the apex of the pedicle-valve. This group of genera is one of very early date for the most part contemporaneous with Paterina, and the existing evidence would indicate that it was not directly ancestral to the line of Trematis-Orbiculoidea (*Discinidæ*). The incipient formation of an internal foraminal tube is seen in several of these genera (Acrotreta, Acrothele, Linnarssonia), and this feature attains its maximum in the true Siphonotreta of the Lower Silurian, where the foramen is still apical and the tube wholly internal. Hence Siphonotreta appears to be a normal termination of this line of descent. Schizambon, in the comprehensive meaning of the term ascribed to it in this work, has the pedicle-passage superficial, and in such shells as *Schizambon fissus*, Kutorga, and var. *Canadensis*, Ami, the condition of this passage is perfectly analogous to that of Siphonotreta, the entire difference being in the enclosure of the latter. In Schizambon the fibres of the pedicle, extending through the foramen near the middle of the pedicle-valve, were directed toward the apex of that valve, and along the concave floor of the external pedicle-groove. The inner aperture of the pedicle-tube in Siphonotreta, corresponds to the "foramen" of Schizambon, and the outer aperture, or true foramen of the former to the grooved umbo of the pedicle-valve in the latter. Hence in Schizambon, thus considered, there is no evidence of a progress of the external aperture, or true foramen, anteriorly beyond the apex of the pedicle-valve. These two genera are but slight departures from the same type of structure, but it would appear that this deviation took place during primordial times, as the typical Schizambon (*S. typicalis*, Walcott) is a primordial fossil. The newly described genus Trematobolus, Matthew* (*T. insignis*, Matthew, type), appears to be another primordial representative of this structure, with the tubular enclosure of the pedicle more highly devel-

* Canadian Record of Science, January, 1893, pp. 277–279, figs. 1 *a–d*.

oped. Thus all these genera, from Acrothele to Schizambon and Siphonotreta, possess an apical foramen, and the development both of the internal tube and the corresponding external groove has been a gradual one. They represent termini of slightly divergent series; consequently they may all be safely included under the old family designation introduced by Kutorga in 1848, *Siphonotretidæ.*

Crania and its allies (Craniella, Pseudocrania, Pholidops) constitute a group in which there is, thus far, no satisfactory evidence of the existence of the pedicle, and we are left to the inference that this organ became atrophied at a very early growth-stage. The study of recent Cranias has not yet determined this point, but this will probably be ultimately accomplished. At whatever stage of growth the pedicle was lost, we may infer that its disappearance in Crania, and generally in Craniella, was directly followed by a solid fixation of the animal by the substance of one of the valves. In Pholidops there was no such cementation, but at a correspondingly early stage the shell became wholly independent. All these shells with central or subcentral beaks have an external resemblance to Orbiculoidea; the formation of the secondary growth of the valves behind the apices or position of the protoconch, is a further substantial agreement with the Diacaulia as contrasted with the abbreviated posterior peripheral shell-growth in the Mesocaulia (Lingula, Obolus). It is nevertheless to be observed that no trace of a former pedicle-slit, incision or perforation is found on mature or immature shells, and it would be difficult to comprehend in what manner such an essential modification of the shell could be wholly concealed by later growth.* Were the pedicle marginal in primitive growth-stages, and subsequently atrophied, the obliteration of the marginal opening by later resorption and growth would be a readily intelligible process. There is, hence, in this default of evidence, a good reason to doubt the close affinities of Crania and Pholidops to the Diacaulia. Present knowledge would seem to indicate that they were primarily of the type of the Mesocaulia, and that their resemblance to the Diacaulia is

* Quite early conditions of *Crania siluriana* and *Craniella Hamiltoniæ*, from 1.5 to .5 mm. in diameter, are fully cemented. Examples of *Pholidops Hamiltoniæ*, not above .5 mm. in diameter, give no indication of a pedicle-passage or surface characters not present in the adult.

wholly of secondary growth.* Waagen's term for this group Gastropegmata or Craniacea may, therefore, prove equivalent to each of these other two divisions.

The great gulf which has seemed to exist between the Inarticulate or Lyopomatous, and the Articulate or Arthropomatous divisions of the Class Brachiopoda; those without teeth and those with teeth; those with a largely corneous shell, and those whose shell is essentially calcareous, is not yet fully spanned at many points.

These divisions were based upon the study of living brachiopods in which all the characteristic differences are pronounced and fixed. We naturally expect to find, however, among the early brachiopods, in which the adjustment of the organism to its conditions was highly sensitive, that the oscillation and specialization of characters has been very rapid. The development of articulating processes has already been noticed among the linguloids, in Barroisella, Tomasina and Trimerella, among the oboloids in Spondylobolus, and among the siphonotretoids in Trematobolus. It is known that the shell of many inarticulates is almost wholly calcareous, as in the *Trimerellidæ* and all of the so-termed Gasteropegmata. The alteration in the nature of the shell-substance from the protoconch, or its examplar, Paterina, which appears to be wholly or essentially corneous, to the typical articulate brachiopod, in which the corneous substance is reduced to a thin epidermal film, is a gradual process whose various stages are well understood. In Obolella, Elkania and the early forms of Lingula, the deposition of calcareous salts in the shell was already advanced, these layers alternating with thinner layers of corneous substance. The gradual and eventual predominance of the calcareous shell-matter along both of these lines of development is seen in the ponderous Trimerellids of the later Silurian. The graduation of the corneous Paterina (*Kutorgina Labradorica*, var. *Swantonensis*) through *Kutorgina Labradorica*, and into the true calcareous Kutorginas (*K. cingulata*, *K. Whitfieldi*),

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* Some species of Pholidops (*P. arenaria*, *P. linguloides*) have a terminal submarginal apex; and their resemblance exteriorly to the oboloids is very striking. This is, however, no more than a resemblance, as they show, on the under side, the same mode of peripheral growth beneath the beak as the other forms of the genus in which the umbones are more nearly central.

is similar evidence. In *Kutorgina Latourensis*, Matthew described a minute tooth on either side of the pedicle-opening,* and it has been stated that *K. cingulata* shows faint traces of articulating processes at or near the extremities of the cardinal line.† Such cases indicate, in the texture and composition of the shell, a direct passage from the most primitive inarticulate to the articulate type. In this feature only, the connection between the two divisions of the class is no closer or more clearly manifested than in the instances mentioned, but it has been shown‡ that *Kutorgina cingulata* may retain a pedicle-covering or external sheath, in fact a true deltidium bearing an apical perforation, like that in Clitambonites. A deltidium-like structure is highly developed or fully retained at maturity in Iphidea.

This is evidence of the highest moment, and shows conclusively the line along which the clitambonitoids and strophomenoids have been derived. It is an immediate departure from the primitive type of the brachiopod into the articulate subtype.

Passage from the inarticulate to the articulate plan of structure was thus effected at a very early period; indeed, almost at the outset of the history of the group. The continuance of the two types has since been that of diverging series, constantly widening the structural gap between them. We have no evidence that this chasm has been bridged at any other point than near its source; the inclinations from the one type toward the other, shown in the articulating processes of Barroisella, Tomasina, etc., represent uncompleted accessory lines of development, which were abruptly terminated without accomplishing the full transition. Such forms have left no descendants, so far as known.

Before entering upon a summary of the phyletic relations of the genera of the Articulata, it is important to apprehend the full significance of the modifications here appearing in the structure of the pedicle-passage and the surfaces upon which the muscular bands are implanted; in other words, the origin and development of the deltidium, the deltidial plates and the spoon-shaped muscular platform, or spondylium, which may occur in

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* Illustrations of the Fauna of the St. John Group, No. 3, p. 42. 1885.

† Beecher, American Journal of Science, vol. XLIV, p. 138. 1892.

‡ Beecher, *loc. cit.*

either or both valves, and may be supported or not supported by a median septum.

The *deltidium* and *deltidial plates*, though similar in functions, are profoundly distinct, both in origin and structure. The former is primitive and fundamental, the latter is wholly secondary; a replacement of, but never a derivative from the former. In the foregoing discussions of the genera these parts have been distinguished simply by the designations generally current; the term deltidium referring exclusively to the convex external portion of the pedicle-sheath, such as is found in Clitambonites, Strophomena, Rafinesquina, and their allies, and which, under no condition, shows evidence of composition or consolidation of separate parts. The term *deltidial plates* has been applied to that condition of the external sheath in which a division into component parts is evident, as in Athyris, Atrypa, Merista, the terebratuloids, etc.; or inferential, as in Cyrtia and Cyrtina. The terminology is here so imperfect as easily to cause confusion, and though it had not seemed needful heretofore to suggest an improvement, it has become necessary, for the proper consideration of the subject, to employ a more distinctive expression for these fundamentally different structures. The secondary structures known as *the deltidial plates*, whether already discrete as in the terebratuloids, rhynchonelloids and meristoids, or solidly coalesced, as in Nucleospira, Parazyga, Cyrtia and Cyrtina, will henceforward be termed the *deltarium*, in application to the parts as a whole, or the *deltaria* in referring to the component plates. It may also prove convenient to adopt the term introduced by Bronn, *pseudodeltidium*, for the coalesced condition of the deltaria in Spirifer, Cyrtia, etc., as this is its original meaning; but the significance of the term will be subordinate to that of *deltarium.*

The researches by Kowalevski* upon the development and detailed anatomy of Thecidea (Lacazella) and Cistella (=Argiope, Kow.) have recently been interpreted in the bearing upon these structures by Beecher, who has also added new data derived from the study of *Magellania flavescens* and *Terebratula septentrionalis*. *Thecidea*, or *Lacazella Mediterranea*, is the

* Observations on the Development of the Brachiopoda; Proceedings of the Session of the Imperial Society of Amateur Naturalists, etc., held at the University of Moscow, Eleventh year, vol. XIV.

latest and only existing brachiopod which retains a true deltidium at maturity. During the cephalula stage of the embryo, before the inversion of the mantle lobes to enclose the head, two shell-plates begin to form, one on the inner side of the dorsal mantle lobe, the other directly opposite to it on the outer surface of that portion of the body which subsequently becomes the pedicle.

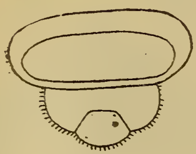

Fig. 252.

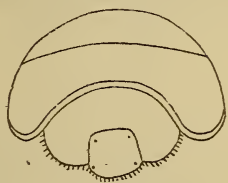

Fig. 254.

Fig. 257.

Fig. 253.

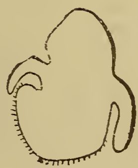

Fig. 255.

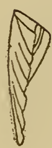

Fig. 256.

Fig 258.

Thecidea (Lacazella) Mediterranea.

Fig. 252. Cephalula, dorsal side; showing below, the cephalic segment with eye spots, and on the upper segment the dorsal shell-plate.

Fig. 253. Dorso-ventral longitudinal section of cephalula; below is the cephalic segment, at the right the dorsal mantle lobe, the thick line on its inner margin representing the beginning of the dorsal valve, and the similar line on the adjoining side of th body the incipient deltidium.

Fig. 254. A later growth stage, in which the mantle lobes have turned downward. The body shell-plate is seen in the upper part of the figure.

Fig. 255. Dorso-ventral longitudinal section of the preceding; showing the inversion of both mantle lobes. The relations of the dorsal and body (deltidium) plates are indicated by the heavy lines at the right. The ventral plate is also seen on the lobe at the left.

Fig. 256. Profile of a very young *Leptœna rhomboidalis*, oriented to correspond with the foregoing figures.

Figs. 257, 258. Views of adult *Thecidea mediterranea* similarly placed.

(Beecher, figs. 252–255, adapted from Kowalevski.)

In this condition of growth the ventral lobe of the mantle is but slightly developed and bears no shell-plates. These features are seen in the accompanying figure of a longitudinal section of such an embryo. In the directly following growth-stage the reversion of the mantle lobes has taken place; the shell-plate before on the inner surface of the dorsal lobe is now on its outer surface, and assumes the normal position of the dorsal or brachial valve. A corresponding plate has developed on the outer surface of the ventral mantle lobe, and between the inner edges of these two plates lies the great pedicle which bears on its dorsal side a third plate, meeting the dorsal, but widely separated from the ventral plate. This third plate is the incipient deltidium. The deltidium is, thus, not a secretion from the mantle, but from the body of the embryo, and it has been shown that the shell-puncta-

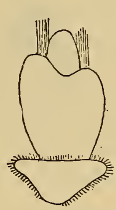

Fig. 259.

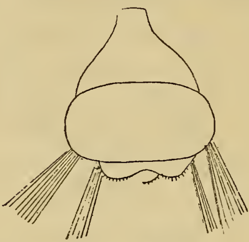

Fig. 261.

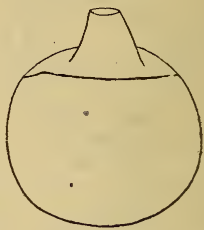

Fig. 263.

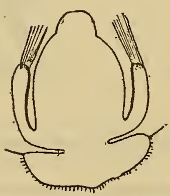

Fig. 260.

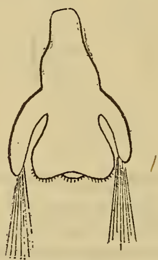

Fig. 262.

Fig. 264.

Cistella Neapolitana.

Fig. 259. The complete cephalula stage.

Fig. 260. Longitudinal section of same; the shell-secreting surfaces are represented by heavy lines.

Fig. 261. The larva after inversion of the mantle lobes.

Fig. 262. Longitudinal section based on the preceding. The shell-bearing surfaces are now on the outside of the animal, the large pedicle extending upward.

Figs. 263, 264. Dorsal and profile views of a very young shell; showing the large posterior opening between the valves and the thick pedicle.

(Beecher; adapted from Kowalevski and Shipley.)

tions, which are usually present in the valves of the deltidium-bearing species, such as *Leptæna rhomboidalis*, *Chonetes scitula*, etc., do not exist in the deltidium.*

In the corresponding stages of growth in Cistella and Terebratulina, there is no evidence of this body-plate, no indi-

* In Aulosteges the surface of the deltidium is covered with short spinules or tubercles. Such spinules in the productoids imply a punctation of the shell, wherever occurring on the valves, but an examination of the deltidium in this genus indicates that the secondary modification of the surface of the deltidium is not accompanied with a punctate structure.

cation in any growth-stage of a deltidium, but the pedicle-passage formed by the ultimate union of the valves at their cardinal extremities remains uncovered until a comparatively late stage. By removing the shell from adult specimens of

Fig. 265.

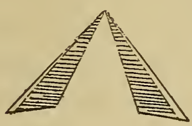

Fig. 266.

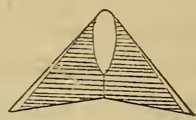

Fig. 267.

Fig. 265. Delthyrium of a young *Rhynchonella*.
Fig. 266. The same, at a later stage, with two triangular deltaria.
Fig. 267. The same, at completed growth of the deltaria.

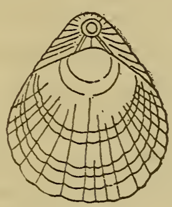

Fig. 268

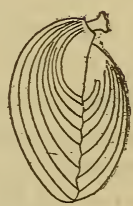

Fig. 269.

Figs. 268, 269. Dorsal and profile views of *Magellania flavescens;* showing deltaria and pedicle.

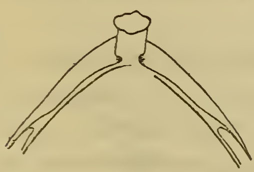

Fig. 270.

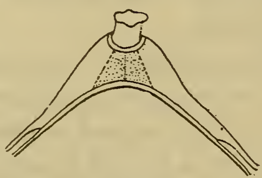

Fig. 271.

Fig. 270. Dorsal view of the umbonal portion of an adult *Terebratulina septentrionalis*, with the shell removed by acid; showing slight secondary extensions of the ventral mantle at the base of the pedicle, small deltaria only being formed in this species.
Fig. 271. A similar preparation of *Magellania flavescens;* showing the complete envelopment of the base of the pedicle by secondary expansions of the ventral mantle, which have formed the deltaria, as shown in fig. 268. (Beecher.)

Terebratulina and Magellania in which the deltaria have become more or less completely developed, it has been found that these plates are derived from two secondary expansions of the mantle of the pedicle-valve enveloping the base of the pedicle.*

* Beecher, *loc. cit.*

These manifest themselves only in later or post-larval growth-stages, and as they are a product of the mantle lobes, may partake of the same punctate structure as the valves.

These plates may unite along the median line, obliterate the foramen, or even extinguish all trace of their original division, as frequently seen in Spirifer, Cyrtia and Cyrtina (*pseudodeltidium*), thus simulating in every respect the true deltidium; though it is now evident that these and the deltidium are of fundamentally different nature. These structures, then, become at once a most important basis of classification among the articulate Brachiopods.

In this work the term *spondylium* has been applied to the spoon shaped plate which, when present, is usually found in the pedicle-valve only, but among the pentameroids frequently occurs in both valves. It has become evident since the introduction of the term that these processes in the two valves, though similar in aspect, are similar neither in origin nor function, and it becomes necessary to modify the application of this term. Hence it is proposed to restrict the term *spondylium* to the plate existing in the pedicle-valve, and to the plates of the brachial valve, whether united or discrete, the name *cruralium* will be applied. The distinction of the parts is necessary to a proper apprehension of their value.

The *spondylium* is an area of muscular implantation. In its early or incipient condition it is evident that it originates from the convergence and coalescence of the dental lamellæ, and forms a receptacle for the proximal portion of the pedicle, and for the capsular or pedicle muscles. In Clitambonites and Pentamerus, where it attains its greatest development, it bears all the muscles of the valve, the central adductor, and the lateral diductor scars being often clearly defined, while the posterior portion of the plate is still reserved for the attachment of the pedicle, if functional. Considering this structure in its incipient condition, where, as in Orthis, it is represented only by the convergent dental plates which usually unite with, or rest upon the bottom of the valve and enclose only the base of the pedicle and its muscles, it will be evident that the plate is actually but a modification of the original pedicle-sheath. It is, evidently, the inner moiety of this sheath surrounding the pedicle, which has become involved or enclosed by the growth of the pedicle-valve, and further modified by the development of articulating processes where it comes in contact with the brachial valve. It therefore follows, as a natural inference, that wherever the spondylium is present, whether in the incipient condition or in the more advanced stage of development in which it supports all the muscles of the valve, it is, or has, at some period of growth, been accompanied by the *external* portion of the sheath, which is termed the deltidium. Thus the spondylium appears to be but the complement of the deltidium, or the original plate formed upon the body of the embryo, and that portion of the adult shell to which the term deltidium has been applied, is the other part of the original or primitive deltidial plate or pedicle sheath. Here again our terminology seems at fault and should be further adapted to the proper conception of these structures. Should the term *prodeltidium* be employed for the primitive body plate or the pedicle sheath in its entirety, we shall then have the terms *spondylium* and *deltidium* applied to corresponding and equivalent modified parts of this plate, the former internal, the latter external.

The adult condition of the shell does not always furnish complete, and sometimes not even suggestive evidence of the relations of the spondylium and deltidium. For example, in the genus ORTHIS and its various subdivisions, the delthyrium is almost always open at maturity and indeed all through the later growth-stages of the shell. The deltidium unquestionably existed at an early stage and has usually become resorbed long before evidences of maturity in other respects are assumed; the spondylium, also, does not pass beyond a condition which makes the pedicle-cavity a clearly defined feature of the interior. In more elementary or less modified orthoid structures like BILLINGSELLA, PROTORTHIS, and the *Orthis deflecta* and *O. loricula* (see Plate V A, figs. 30, 31), the deltidium is fully retained at maturity, while the spondylium remains in its condition of a simple pedicle-cavity. The coexistence of both features with a high degree of development, as in CLITAMBONITES, POLYTŒCHIA, etc., indicates a more primitive condition than in ORTHIS, though in such cases the extension of the spondylium to such a degree as to carry all the muscular bands of the pedicle-valve must be regarded as a secondary modification of this organ. In PENTAMERUS and allied genera, where the spondylium attains its greatest development, the deltidium is usually lost, but when retained is very thin and has a concave exterior, a form doubtless largely due to the arching of the umbo of the pedicle-valve over the full, procumbent beak of the brachial valve. The spondylium occurs in various modified conditions; in cases where the teeth are wholly without dental lamellæ, or where such lamellæ do not extend to the bottom of the valve, it seems necessary to regard them as instances of degeneracy or resorption of the primitive spondylium. As the growth, modification and disappearance of the differential parts of the prodeltidium do not progress *pari passu*, there will frequently be examples of one being retained when the other has disappeared. A remarkable illustration of this fact is afforded by the genus Camarophoria, which possesses a highly developed spondylium, while the deltidium has been resorbed and secondary deltidial plates or deltaria formed about the pedicle-passage.

In the fundamental division of the Articulata two groups will be recognized, one embracing those forms in which the prodeltidium is represented by the deltidium and spondylium, one or both; the other a group in which the prodeltidium has been fully modified, resorbed or replaced. The former group is equivalent to Waagen's suborder, Aphaneropegmata (1883), with the addition of Thecidea and its allies, and to Beecher's Protemata (1891), excepting the genus Tropidoleptus. So deep-seated does this difference in these groups of genera appear to be, that examples of such combinations of primary and secondary conditions as shown by Camarophoria, are of the rarest occurrence.

The spoon-shaped process of the brachial-valve, which has been termed the *cruralium*, is a feature of more fugitive value. It is formed by the convergence or union of the crural plates, and it may rest upon the inner surface of the valve, or like the spondylium, be supported by a median septum. More often the crural plates, when highly developed, stand erect upon the valve and do not unite, but their position is highly variable, and it has been shown that in Pentamerus, Conchidium, and their allied forms, the union of these plates is not of first importance as a generic character. When the crural plates extend to the bottom of the valve as distinct septa, they simply inclose an extension of the median incision of the hinge-plate. It has become evident, from a study of the hinge-plate, that the so-called visceral foramen which perforates it, and which is often present in Athyris, Rensselæria, Cryptonella, etc., is a remnant of this aperture, the remainder of the median opening having become filled by a testaceous secretion. There is every reason to believe that the visceral foramen was actually traversed by the lower alimentary canal, and if this were true, then the deep and narrow median chamber bounded by the crural plates must also have enclosed the terminal portion of the intestine. Within it lie the elongate scars of the adductor muscles, and when the chamber is elevated by the completed formation of a cruralium, these scars are still within it, as in the case of the spondylium. It is therefore the morphic equivalent of the spondylium. Its supporting median septum, when present, is composed of two lamellæ, each representing one of the coalesced or adherent crural plates.*

The unsupported convex internal plate or "shoe-lifter" in the pedicle-valve of Merista and Dicamara must be interpreted as an entirely different structure from the spondylium. It is not produced by convergent dental plates, but these, on the contrary, are divergent, the arched plate uniting its inner edges. Its origin and the reason of its existence are still obscure. The readiness with which the filling of the cavity between this plate and the outer wall of the valve separates from the shell, carrying with it the enclosing walls, leads to the suggestion that the "shoe-lifter" may be the innermost lamina of the shell separated from the rest of the valve and leaving it thinner in this region. This plate bears the muscular bands, in whole or in part, upon its convex surface. In Eichwaldia it has been observed that the small internal plate of the pedicle-valve is probably a modified condition of the deltidium, as the pedicle passes beneath it, while the platform in Aulacorhynchus may prove to be wholly of muscular origin.

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*In the pentameroids the median septum of the pedicle-valve supporting the spondylium, is formed in a similar manner by a continuation and coalescence of the dental plates, and wherever the median supporting septum exists in this group, it will probably be found to have this composition. Median and lateral septa, however, in the valves of the Brachiopoda, have a highly diverse origin in different cases. In most instances, except where bearing spondylia, they are evidently of muscular origin and surfaces of muscular attachment, as shown in Spiriferina (see figure 42, page 53, and remarks in foot-notes, Part I, p. 49); while in the Trimerellidæ they appear to be the residuum left by the resorption of a thick testaceous deposition about and beneath the area of muscular insertion.

The compound "shoe-lifter," divided by the median septum in the brachial valve of DICAMARA, is like the corresponding plate in the pedicle-valve in having no connection with, or origin from the articulating apparatus. This plate is not a cruralium, and in precisely the same sense that the simple "shoe-lifter" is not a spondylium. Such cases as MERISTA and DICAMARA are, therefore, not to be cited as examples of the concurrence of spondylium and cruralium, with the secondary condition of the pedicle-covering or deltarium, but are, rather, illustrations of the production of parts which may be similar in function in the mature condition, but are totally distinct in origin; in other words, interesting instances of morphic equivalents.

The *cardinal area* is a feature more generally developed among the forms included by WAAGEN under his term APHANEROPEGMATA, (PROTREMATA, Beecher) that is, among forms possessing the deltidium, but it is very irregular in its occurrence among all the articulate Brachiopoda. The genus SPIRIFER furnishes a most striking instance of its persistence in the deltarium-bearing shells; its usual absence in PENTAMERUS and CONCHIDIUM serves to demonstrate that it is not an indispensable character of its group. It is probable that the existence of this area has little fundamental connection with the condition of the pedicle-passage. It is a very palpable fact that there is a much more intimate relation between this area and the general form of the shell; thus in the elongate shells, like the terebratuloids, meristoids, retzioids and the pentameroids for the most part, there is no such area present. Where the form of the shell is more generally transverse, as among the ORTHIDÆ, in STROPHOMENA, CLITAMBONIETS, DERBYA, SPIRIFER, etc, the area is highly developed. This area is a characteristic feature of all early deltidium-bearing species, and, where it manifests itself occasionally in one of these groups which has for the most part lost or never developed this area, as in PORAMBONITES, GYPIDULA and PENTAMERELLA among the pentameroids, its appearance may be regarded as the resumption of a primitive or original character which was normal for that division of the Articulates in some period of its history.

We similarly meet with a cardinal area in an early rhynchonellid type, ORTHORHYNCHULA, and this is an evidence of the first significance as indicating the source from which the extensive group of the Rhynchonellas originated. These are shells which assumed, at a very early period, the deltarium or secondary condition of the pedicle-covering. It would be presumptuous to assume that a single species of this great group developed a cardinal area, solely from mechanical causes, such as obstructed growth on the posterior margins of the valves. Its presence seems, rather, to suggest the perpetuation of an ancestral character indicating that these modified shells have been derived from a more primitive condition in which the cardinal area was normal, and, no doubt, accompanied by a deltidium. In the absence of further evidence such a character is of much importance.

Under the guidance of the structural features above considered, the main lines of derivation of the Articulate genera are more readily apprehended.

The earliest known representatives of a given group of genera are not always the most primitive in structure. In the instance cited in the preceding paragraph, *Orthorhynchula Linneyi* is perhaps, by itself considered, the closest expression of the fudamental stock from which the rhynchonellids have been derived, but it is by no means the earliest of the group. It is known only in the latest fauna of the Lower Silurian, while in the earlier faunas Protorhyncha, Rhynchotrema and Camarotœchia have attained an abundant development. Orthorhynchula either represents a resumption of the primitive type, subsequent to such modifications as appear in the earlier rhynchonelloid genera, or a continuation of that type, without modification, through pre-existing forms as yet unknown. Such instances could be multiplied, as facts of similar import are constantly recurring, and a careful consideration of the stage of development or decline of each separate and individual organ is requisite to determine how far the organism in question is a direct or modified outcome of the fundamental type; or a degenerate or senile relapse, after modification, to phyletic immaturity.

The most elementary structure, then, observable, among the Articulate Brachiopods is the combination of the deltidium with a distinct pedicle-cavity, whose anterior margins are not free, and whose lateral walls or dental lamellæ are not highly developed; these features being accompanied by gently and unequally biconvex valves, well-defined cardinal areas and elongate hinge-line; producing, in effect, a generally orthoid expression, both of interior and exterior. This is the condition of Billingsella of the Cambrian, *Orthis loricula* and *O. deflecta* of the Trenton group, and *O.? laurentina* of the Hudson . iver fauna, and it is continued without essential modification, except in the gradual contraction of the pedicle-cavity and deltidium, into Strophomena of the Silurian, its allies and successors, Orthothetes of the Devonian and Derbya of the Carboniferous, Hipparionyx Triplecia, Streptorhynchus, etc., into Leptæna, Rafinesquina, Stropheodonta, Plectambonites, Chonetes and Productus.

The tendency to contract the pedicle-cavity and deltidium presents its extreme manifestation in the Devonian forms of Stropheodonta, Strophonella and Leptostrophia, where it has become almost, and sometimes quite obliterated, and the entire pedicle and umbonal cavity filled with testaceous secretions. Such filling can occur only in a discarded and useless space, after the pedicle has ceased to be functional. A morphological consideration of much importance presents itself here, as well as in any other groups of genera where the shells attain great size. The evidence is very direct from the study of the structural features as given above, that the entire muscular system on the ventral side of the body is, in primitive forms, inserted upon the base of the pedicle-cavity. This is apparent from a study of such a shell as *Orthis callactis*, where it is perfectly clear that no muscular bands were attached to the pedicle-valve ouside the limits of this strong and condensed posterior area, which is but a sessile spondylium. The contraction of this pedicle-cavity is accompanied by (whether in relation of cause to effect can not be stated) a diffusion of the area of muscular attachment, and when the shells are large, as in Strophomena, Rafinesquina, Stropheodonta, Orthothetes, Derbya, etc., the necessity for powerful muscles or some similar cause, magnifies this expansion of the muscular area until the original contents of the pedicle cavity may be represented by enormous muscles whose scars extend almost to the anterior margin of the valve, as in Hipparionyx and Rhipidomella.

In this great group of genera there are two types of contour, one as in Leptæna being normally convexo-concave, that is, with the pedicle-valve convex and the brachial valve parallel to it and concave; the other, as in Strophomena, having this contour reversed, the pedicle-valve at first convex, but subsequently and through all later growth-stages concave, while the brachial valve becomes correspondingly convex. In both cases, as in other brachiopods, the primitive and post-embryonic valves are both convex. The peculiar reversal of contour, which is never more extremely manifested than in this group, but nevertheless occurs in other genera, such as Atrypa, many Rhynchonellas, etc., is a purely secondary condition. Its causes have not been fully investigated, but an unequal peripheral growth of the two valves arising from inequality in the size of the ventral and dorsal mantle lobes, seems to be a partial if not sufficient explanation of its existence. As either the presence or absence of this reversal is a normal secondary condition, it is not possible to give it great weight in a broader grouping of the genera, for we find that Strophonella is but a reversed Stropheodonta, passing through similar phases; Amphistrophia is a reversed Brachyprion, both existing in faunas of the same age, and Strophomena is a reversed Rafinesquina, both similarly coexistent.

With this presentation of the subject it seems neither necessary nor desirable to propose any broad division of this group of genera. In 1846 King proposed to embrace Strophomena and its allies, in the family *Strophomenidæ.* The large number of generic values allied to Strophomena, which have been determined since that date, make this comprehensive family divisible *ad libitum, sed non in majorem Dei gloriam.*

The calcareous fixation of the pedicle-valve to extraneous bodies after the closure of the pedicle-passage and atrophy of the pedicle itself, is repeatedly manifested by these shells. This, as already shown, is a pre-adult condition in Orthothetes, Derbya and Streptorhynchus, the shell becoming wholly free before full growth was attained; but in Leptænisca and Davidsonia the attachment was maintained throughout the later existence of the shell.

The impressions left by the spiral arms upon the interior of the valves in Davidsonia and Leptænisca, and also observed by Davidson in specimens of *Rafinesquina Jukesi* and *Leptœna rhomboidalis,* show a complete correspondence in the direction and curvature of the coils, and we are left to infer that other members of the *Strophomenidæ* were in agreement with this structure, and, hence, that the arms in their uncalcified condition approached nearer the calcified spirals of *Koninckinidæ* (Cœlospira, Koninckina, etc.) than to those of any other group.

The condition of the pedicle passage possessed by these shells is maintained by Chonetes and Productus, without great modification in other respects. Chonetes possesses a marginal row of strong cardinal spines or tubes communicating with the internal cavity of the valves. Yet we are acquainted with forms (*e. g.*, *Anoplia nucleata*) in which these spine-tubes do not manifest themselves externally. Productus is normally covered with spines on one or both valves, but there are some species which possess none. The cardinal area, deltidium and teeth, which are retained in Chonetes, Productella, Strophalosia and Aulosteges, become wholly obliterated in the direct line of productoid development. In all these forms the "reniform impressions" retained on the inner surface of the brachial valve, are evidence of fleshy brachia possessing a similar curvature to those of the *Strophomenidæ*.

This group of genera has long been designated by the family name *Productidæ* introduced by Gray in 1840, though, in correlating the various divisions of Waagen's group Aphaneropegmata, there would be excellent reason for considering the chonetids and productids components of a subfamily inferior in value to the *Strophomenidæ* and equivalent to the divisions *Orthothetinæ*, Waagen, 1884, and *Rafinesquininæ*, Schuchert (*emendatus*), 1893.*

Returning to the point of departure, we shall find that in the genus Orthis, which in its broadest significance is tantamount to the family *Orthidæ*, Woodward, 1852, since the elimination of several heterogeneous branches, the deltidium was resorbed at an early stage of growth, leaving the delthyrium a wide uncovered aperture during all the later stages of existence. The pedicle in this group of shells was undoubtedly large and vigorously functional throughout all mature conditions, as it is of very rare occurrence that any secretions of calcareous matter are found in the apex of the delthyrium, such as are frequently observed in mature and senile conditions of Spirifer. The sharp delimitation of the pedicle-cavity containing all the muscular scars of the pedicle-valve, which occurs in the earlier forms (those

* American Geologist, vol. XI, p. 153.

of Orthis in its restricted meaning, such as *O. callactis*, *O. costalis*, etc.) is maintained in all the numerous subdivisions of the genus, with the exception of Rhipidomella in which there is a great expansion of the muscular scars, similar to that in the *Strophomenidæ* and to which reference has just been made. Otherwise the sessile condition of the spondylium is not modified throughout the entire history of this group.

The elevation of the spondylioid plate or the base of the pedicle-cavity into a true spondylium, is a phenomenon of equally early age to the two conditions already discussed. It appears in a highly-developed state in conjunction with the unmodified deltidium, first in Protorthis of the Cambrian, then in Polytœchia, Syntrophia, Clitambonites and Scenidium of the early and later Silurian and the Devonian.

A parallel line of development is exhibited by spondylium-bearing forms in which the deltidium disappeared at a very early period, and the shells possess a trihedral, generally coarsely plicated and decidedly rhynchonelloid exterior. It seems highly probable that this line was differentiated in the early Cambrian, as indications of this structure are observable in some primordial species, as *Camerella? minor*, Walcott, and *Stricklandinia? Balcletchensis*, Davidson; in the Silurian it is represented by Camarella and Parastrophia, also by the more rotund and more finely plicate shells, Anastrophia, Porambonites, Lycophoria and Nœtlingia.

The genera last named are not homogeneous with the others in the phases of development which they represent, all retaining the cardinal areas more or less distinctly, while Lycophoria and Nœtlingia also possess a cardinal process in the brachial valve.

The presence of the cardinal area in such early structures must be regarded as a retention rather than a resumption of a primitive character.

Whatever may be the oscillation in form and the variation in secondary characters presented by Camarella, Parastrophia and their allies, present evidence indicates that they must be regarded as the genetic precursors, as they are the temporal precedents of the great group of true pentameroids (Pentamerus, Capellinia, Conchidium, Barrandella, Sieberella, Pentamerella, Gypidula, Stricklandinia, Amphigenia) and, indeed, the last of these pentameroids, Camarophoria, of the Carboniferous and Permian faunas, is an exemplification of, in fact a return to the rhynchonelloid exterior and the camerellid aspect, with the addition of deltaria in the delthyrium.

While considering in detail the pentameroid genera mentioned above we have seen that in certain of them, as Pentamerus and Conchidium, a true deltidium[1] is often retained, though it is a fragile structure rendered concave by the arched growth of the umbones of the valves, and is generally lost. In others (Gypidula, Pentamerella) there are occasionally evidences of lateral, erect or convex growths upon the margins of the delthyrium, which may be interpreted either as remnants of a resorbed convex deltidium, or as highly accelerated secondary deltaria Every now and then specimens will show a clearly developed cardinal area, always in Stricklandinia, frequently and normally in Gypidula, rarely in Pentamerella. Stricklandinia possesses so straight and long a hinge, so sharply defined an area and so short a spondylium, that it is more natural to regard this genus as the accompaniment rather than the close organic kin of the other pentameroids, deriving its differentials directly from those long and straight-hinged shells of the early Silurian, which have been placed under the genus Syntrophia.

It will now appear not a matter of inexplicable aberrancy that the spondylium presents itself in the great secondary groups comprising the rhynchonellids and those shells with calcified brachidia. Hence we meet with it in Cyrtina and Camarospira in a highly developed state, and in Camarotœchia in a less advanced condition, while Amphigenia presents the remarkable combination of a spondylium coexistent with a completely rensselærioid shell structure (that is, form, contour, muscular markings and articulating apparatus) and rhynchonelloid brachial supports.

Attention has already been directed to the fact that the *Rhynchonellidæ*, early in their history, occasionally retain a well-defined cardinal area and that, in default of other evidence, the presence of this character may be regarded as indicative of the common origin of Orthis, the *Strophomenidæ* and the Rhynchonellas. The earliest phyletic stages of the rhynchonellids must have been highly accelerated, for there is no evidence of any which has yet shown the slightest trace of a deltidium. Nevertheless the early forms of the Silurian, such as ORTHORHYNCHULA and PROTORHYNCHA, rarely show any indication of deltaria at maturity, but the delthyrium in its final stage is unobstructed and simple, as in young conditions of later rhynchonellids in which the deltaria fully develop.

We may look upon the *RHYNCHONELLIDÆ* as a family whose characters became established very early and have been perpetuated up to the present without wide departure at any time from the early derived type.

In the study of the multifold variations of the articulates bearing calcified spiral brachial supports, the HELICOPEGMATA (Waagen, 1883), the conclusion has enforced itself that the degree of solidification of the brachia in this group is to be regarded as an index of differentiation. To illustrate: there is no evidence for assuming that the single evolution made by the spiral in PROTOZYGA and HALLINA represents an incomplete spiculization of the brachia, or that the spiniform and discrete jugal processes in SPIRIFER, persisting throughout the genus, do not fully exemplify the adult condition of the jugum (= loop) in these shells. The mode of spiculation of the brachia in such of the living terebratuloids, in which the solidification is direct or without complicated metamorphoses, is, on the whole, confirmatory of this inference; but as there is no living representative of the HELICOPEGMATA, the evidence in regard to the mode and degree of spiculation in the group, derived from the existing loop-bearing shells in which the brachial supports pass through highly complicated metamorphoses, is not altogether germane. In such intricate structures as the brachidia of ATHYRIS, KAYSERIA, KONINCKINA, etc., there can be little doubt that the calcified apparatus represents the full extent of the fleshy brachia, simply if for no other reason, because the further expansion of the brachial lamellæ would not be possible. Moreover, in the spiculation of the spirals in all these old shells there have been no changes of form in later growth, except those proceeding from the normal process of resorption and deposition necessary for increase in size and length. The reason why, in the HELICOPEGMATA, spiculation should be complete, while in the ANCYLOBRACHIA or terebratuloids, it does not extend beyond the loop or the lateral extensions of the brachia, in the *RHYNCHONELLIDÆ* affects only the crura and in the *Strophomenidæ* does not occur even in the most elementary condition, is for future investigations to ascertain.

The form of the paired spirals varies but little, except under the necessity of conforming to the interior cavity of the valves. Their inclination and direction is a feature of much significance when considered with reference to the development of the entire shell. It is the loop, or to employ a term more appropriate in view of the homologies of the spire-, and loop-bearing shells, the *jugum*, however, which is subject to the most frequent variation in form and which serves as the generic index. When the spirals are directed outward toward the lateral margins of the valves, the jugum seems to be much more variable than in shells where the spirals are introverted or take some intermediate position. In the latter there is a much greater variation in the position of the loop upon the primary lamellæ than occurs in the former.

The earliest spire-bearing shells yet discovered are the simplest in the structure of the brachidium. Hallina, Protozyga, Cyclospira of the Lower Silurian possess brachidia which are little else than one or two volutions of the calcified lamellæ with a slight inclination toward each other and the median axis of the shell. Zygospira and Glassia, the contemporaries and successors of these primitive structures show progressed conditions of the same form of brachidium. In these genera, however, there is a slight deviation in the vertical axes of the spirals from the transverse axis of the shell, the apices being inclined somewhat toward the brachial valve, and this tendency to lateral revolution in the spiral cones is carried to its extreme in the genus Atrypa, where the multispiral cones of the fully matured forms of the Devonian may sometimes have their axes nearly parallel. This is the termination of all revolution of the cones, a change through an arc of less than 90°, probably due in a large degree to alterations in the form of the internal cavity of the valves; and the fact that this revolution here ceases strictly delimits the group of forms bearing spirals of this type. (*Atrypidæ.*)

It is well to emphasize the fact, lest misconceptions already set on foot should become prevalent, that no wider revolution of the spiral cones exists. It is true that there is a difference of 180° in the position of the axes of the spiral cones in Cyclospira and Spirifer, but the spirals have never, by gradual changes, revol ed from their inverted position in the former to their everted position in the latter. Such a process might have been possible, but had it actually occurred, the forms resulting would have been totally different in structure from any known. Instead of having the primary lamellæ and jugum on the dorsal side as in all shells with everted spirals, these parts would lie on the ventral side of the shell. It must hence be inferred that the *Spiriferidæ,* the *Athyridæ,* the *Meristidæ* and all genera with everted brachidia, are related to the *Atrypidæ* only through their early ancestral forms.

The Lower Silurian faunas have furnished no evidence of Helicopegmata with everted spirals, and this hiatus in our knowledge forbids any satisfactory deductions as to the source or derivation of these forms. It is true in a general sense that the eversion of the spirals is accompanied by a convexity of both valves, just as the inverted spirals of the *Atrypidæ* are associated with valves of notably unequal depth. Still, among the latter, Glassia possesses biconvex valves, while of the former, the group composed of Cœlospira, Anoplotheca, Koninckina and Amphiclina is characterized by convexo-plane or convexo-concave valves. In this group also the apices of the spirals are not directed toward the lateral commissures of the valves, but toward the lateral slopes of the pedicle-valve, such a form and direction being a necessary outcome of the contracted interior space.

We are at present disposed to believe that among the early Silurian species will be found some whose spiral ribbon deviates outwardly from the vertical plane to the same degree as it is found to incline inwardly in Cyclospira and Protozyga. Indeed in *Cyclospira bisulcata* itself the spiral sometimes lies so nearly in the vertical plane that the inward inclination of the apices is not always positive. Only some such form of the earlier faunas could have been the progenitor of the everted spirals.

In the *Atrypidæ* possibilities of variation in the form of the jugum were much restricted; in the other groups of the Helicopegmata these were very great and resulted in the production of a wonderful series of modifications whose relations it is not necessary to rehearse here. The extreme range of these modifications is seen in the simple termination of the jugum in Whitfieldella, Rhynchospira, etc., the bifurcate extremity in Meristina, Eumetria and Retzia, their terminal branches finally becoming coextensive in Kayseria, Diplospirella, etc., with the lamellæ of the primary spirals and thus forming a second pair of spiral cones. This complication of the brachidium is effected only late in the history of the various groups producing them. Koninckina and Amphiclina are double-spiraled convexo-concave shells which are the post-palæozoic and final representatives of Anoplotheca and Cœlospira. Pexidella and Diplospirella, of the St. Cassian beds, are double-spiraled athyroids; Kayseria of the middle Devonian, which is the only double-spiraled form known in the Palæozoic, appears to be an aberrant and accelerated representative of the stock which by more gradual development produced Retzia and Eumetria.

But one large group of spire-bearing shells retains the cardinal area, namely, the *Spiriferidæ*, a family with everted spirals, one of the earliest to appear and the last to disappear. Its abundant representatives possess the longest of spirals and for the most part these are greatly extended transversely, held at arm's length as it were, unsupported by a connected jugum (except in the more sparsely represented genera Cyrtina and Spiriferina), but in spite of the delicacy of this structure and its apparent mechanical disadvantage in the absence of a continuous jugum, the type of structure maintained its own and multiplied in a most remarkable manner.

The relations of the brachiopods with spiral brachidia, or Helicopegmata, to the Ancylobrachia, or those shells commonly spoken of as the *terebratuloids*, has been a fruitful subject of discussion and given rise to investigations of great astuteness and merit. Reference has already been made to the facts established by Beecher and Schuchert from the development of the brachidium in Zygospira, which show that this atrypid passes through a growth stage in which the brachidium has a simple terebratuloid form, similar to that in the mature condition of Dielasma; that the spirals are formed by the continued growth of the descending lamellæ of the loop beyond the point of their recurvature into the ascending lamellæ. What is thus true of ZYGOSPIRA we must assume to have been equally true of all the spire-bearers, and the analogies thus established between them and the loop-bearing shells are these: The entire loop in DIELASMAS, CRYPTONELLA, etc., corresponds to that portion of the brachidium in the HELICOPEGMATA which lies behind the anterior basal edges of the jugum; the descending lamellæ of the former represent only the posterior portion of the primary lamellæ of the latter, while the ascending lamellæ and transverse connecting band of the ANCYLOBRACHIA are the equivalent of the jugum in the spire-bearers. The spirals, however, are a later development in the individual, and are hence, undoubtedly, a subsequent phyletic condition. Hence it is inferred that the spire-bearing derived their brachidia from a primitive terebratuloid condition, and this derivation has been effected by growth with accompanying resorption.

The progressive modification of the loop in the recent Terebratellids by the resorption of calcareous tissue in the growth of the individual is a well-known fact which has invited the study of many investigators. In such forms this modification is extreme, and is unquestionably complicated by the intimate connection of the loop with the median septum of the brachial valve. With the single exception of TROPIDOLEPTUS there is among the palæozoic genera, no clear evidence that the median septum has shared in, or contributed to the growth-modifications of the brachial supports; nevertheless, the outcome and final result of this growth, with modification, in the most progressed forms of TEREBRATELLA and such palæozoic genera as DIELASMA, CRYPTONELLA, HARTTINA, etc., is the same.

Progressive modification of the brachial supports in both the HELICOPEGMATA and palæozoic ANCYLOBRACHIA being now fully established, it is interesting to observe that the primitive condition of the loop, as in *Dielasma turgida*, is one of simple apposition of the two short brachial processes, at their expanded anterior extremities, having the expression of the mature loop in the genera CENTRONELLA, RENSSELÆRIA, SELENELLA, etc. A simple step further back would afford a condition in which the brachial processes, with their expanded extremities, are not as yet united, but discrete as in the rhynchonellids. A more primitive condition than that in Centronella, or the centronellid stage in Dielasma, could not be different from this.

On the ground of these differences in the conditions of the brachidium and the phyletic stages corresponding with them, it would seem fair to infer that, of the rhynchonellids, the terebratuloids and the spire-bearers, the first is the primitive stock, and the spire-bearers legitimate derivatives from that stock through the terebratuloids, or both of the latter derived along divergent lines from the rhynchonellids.

This conclusion, however coherent and consistent with the geological evidence, will be found to lack stability until the data are sufficient to establish the fact that the brachia themselves, and not alone their calcareous supports, have passed through corresponding phases of growth and derivation. This latter question must long be a matter of legitimate speculation, and, in view of this fact, a few arguments of such a nature in this place will be permissible.

The living representatives of Rhynchonella and Terebratula are animals in which a very considerable part of the brachia does not become sufficiently spiculized to form a continuous calcareous support. In *R.* (*Hemithyris*) *psittacea*, for example, the brachia are as highly developed in the form of coiled spiral arms as in most of the ancient spire-bearers, but their calcareous supports are only the short lamellæ known as the crural processes. All of the living Ancylobrachia which possess a long recurved loop like that of Cryptonella and Dielasma, of the Palæozoic, have an unsupported median unpaired spiral arm, coiled in a direction which is the reverse of that prevailing among the spire-bearers. If, now, we are to interpret the condition of the brachia in the fossil rhynchonellids and terebratuloids from the adult condition of the brachia in their nearest living representatives, it becomes necessary to assume that, on the one hand, the palæozoic rhynchonellids possessed long, coiled, spiral arms, and, on the other, that Dielasma and its palæozoic allies and affines were, when mature, provided with the unpaired coiled arm of Terebratella. This assumption, first, destroys totally the inference above made as to the primitive relation of the rhynchonellids to the terebratuloids and spire-bearers and, secondly, would seem to necessitate a novel and unexpected interpretation of the brachial structure in all the spire-bearers. If Dielasma possessed the median arm, supported at its base by the transverse band of the loop, which corresponds to the jugum of the spire-bearers, then in the Dielasma-stage of Zygospira and other spiriferous shells, where this stage was well defined, there must also have been a median coiled arm of some extent. This median arm, in living forms, is due, as shown by Beecher, to the necessity of finding room for the cilia or tentacles multiplying at the extremities of the brachia. The mere presence of the transverse band in Dielasma and the Dielasma stage of Zygospira implies a similar extension of the brachia and, from this analogy, a median arm. The subsequent growth of the brachia in Zygospira, carrying the calcareous ribbon forward beyond the bases of the loop and into the lateral spiral cones, would not, of itself, afford sufficient reason for assuming that the growth of the brachia at their extremities, which produced the median arm, was necessarily discontinued, but rather that this median-unpaired arm coexisted with the lateral paired spirals. This course of argument, though apparently logical, appears to be based on insufficient premises.

The brachiopods with which we have to deal in the Palæozoic are essentially primitive structures, whether rhynchonellids, terebratuloids or spire-bearers. If the living Rhynchonella and Terebratella, in their mature conditions, possess extensive unsolidified arms, it does not necessarily follow that their early palæozoic representatives were provided with similar uncalcified extensions; on the contrary, it would be much more reasonable and in accordance with our knowledge of natural laws to infer that in these early forms the adult condition of the brachia was more nearly that of immature conditions of these organs in their living representatives. There is a primitive condition of development in the terebratuloids in which the loop is coextensive with the brachia; such we believe to have been the relation of these parts in the mature phases of the primitive terebratuloids as Centronella, Rensselæria, Cryptonella, Dielasma, etc.; in Tropidoleptus, which has been shown to represent a highly primitive phyletic condition of the *Terebratellidæ;* and, too, in the earliest spire-bearers and rhynchonellids. Hence the conclusion above expressed as to the successive phyletic relations of the primitive rhynchonellids, terebratuloids and spire-bearers, based upon the relations and modifications in the form of their brachial supports, is fairly substantiated by the evidence drawn from other data.

Finally, it is important to emphasize the intimate similarity between Rensselæria and the pentameroid genus Amphigenia; genera in which the essential distinction between the typical forms of each lies in the simple loop of the former and the long, expanded, but still discrete crural processes of the latter. Attention has been directed to these similarities and differences, and it has also been pointed out that the spondylium in *Amphigenia elongata* is at times almost reproduced in specimens of *Rensselæria ovoides* where the dental lamellæ are highly developed.

TABLE OF CLASSIFICATION.

Class BRACHIOPODA.

Paterina,* Beecher, 1891.

Sub-class INARTICULATA, Huxley; LYOPOMATA, Owen.

Order MESOCAULIA or LINGULACEA, Waagen.

Family Obolidæ, King.

Obolus, von Eichwald, 1829.
Ungula, Pander, 1830.
Ungulites, Bronn, 1848.
Aulonotreta, Kutorga, 1848.
Acritis, Volborth, 1869.
Schmidtia, Volborth, 1869.
Mickwitzia, Schmidt, 1888.
Spondylobolus, McCoy, 1852.
Obolella, Billings, 1861.
Dicellomus, Hall, 1871.
Elkania, Ford, 1886.
Billingsia, Ford, 1886.
Botsfordia, Matthew, 1893.
Neobolus, Waagen, 1885.
Monobolina, Salter, 1865.

Family Lingulidæ, Gray.

Lingula, Bruguière, 1792.
Pharetra, Bolton, 1798.
Lingularius, Duméril, 1806.
Lingulella, Salter, 1866.
Lingulepis, Hall, 1863.
Leptobolus, Hall, 1871.
Glossina, Phillips, 1848.
Dignomia, Hall, 1871.
Barroisella, Hall, 1892.
Tomasina, Hall, 1892.

Family Trimerellidæ, Davidson and King.

Lakhmina, Œhlert, 1887.
Davidsonella, Waagen, 1885.
Lingulops, Hall, 1871.
Lingulasma, Ulrich, 1889.
Dinobolus, Hall, 1871.
Conradia, Hall, 1862.
Obolellina, Billings, 1871.
Monomerella, Billings, 1871.
Trimerella, Billings, 1862.
Rhinobolus, Hall, 1874.

* The genus Paterina, representing, according to our present knowledge, the fundamental stock or radicle of all the Brachiopods, might be embraced by some of the primitive families, both of the Inarticulata and the Articulata. By placing it in this arrangement, outside both of the great sub-classes, it is the purpose to express the fact that the genus belongs as much to one as to the other, and that it is actually beyond the pale of both as it has not assumed the differential characters of either.

Order DIACAULIA or DISCINACEA, Waagen.

Family Discinidæ, Gray.

Discinolepis, Waagen, 1885.
Paterula, Barrande, 1879.
Schizobolus, Ulrich, 1886.
Trematis, Sharpe, 1847.
Œhlertella, Hall, 1892.
Lingulodiscina, Whitfield, 1890.
Schizocrania, Hall and Whitfield, 1875.
Orbiculoidea, d'Orbigny, 1847.
Schizotreta, Kutorga, 1848.
Lindstroemella, Hall, 1892.
Roemerella, Hall, 1892.

Family Siphonotretidæ, Kutorga, 1848.

Acrothele, Linnarsson, 1876.
Linnarssonia, Walcott, 1885.
Discinopsis, Matthew, 1892.
Acrotreta, Kutorga, 1848.
Conotreta, Walcott, 1889.
Mesotreta, Kutorga, 1848.
Schizambon, Walcott, 1884.
Siphonotreta, de Verneuil, 1845.
Orbicella, d'Orbigny, 1849.
Keyserlingia, Pander, 1861.
Helmersenia, Pander, 1861.

Order GASTEROPEGMATA or CRANIACEA, Waagen.

Family Craniidæ, King.

Crania, Retzius, 1781.
Numulus, Stoboeus, 1732.
Ostracites, Beuth, 1776.
Criopus, Poli, 1791.
Criopoderma, Poli, 1791.
Orbicula, Cuvier, 1798.
Orbicularius, Duméril, 1806.
Craniolites, Schlotheim, 1820.
Choniopora, Schauroth, 1854.
Craniella, Œhlert, 1887.
Cardinocrania, Waagen, 1885.
Pholidops, Hall, 1869.
Craniops, Hall, 1859.
Pseudocrania, McCoy, 1851.
Palæocrania, Quenstedt, 1871.

Sub-class ARTICULATA, Huxley; ARTHROPOMATA, Owen.

Order PROTREMATA,* Beecher.

Family Kutorginidæ,† Schuchert.

Kutorgina, Billings, 1861.
Schizopholis, Waagen, 1885.
Volborthia, von Möller, 1873.
Iphidea, Billings, 1872.

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* In employing as the fundamental divisional distinction in the Articulata, the presence of the deltidium or the deltidial plates, the term Protremata covers better than any other those genera in which the primitive pedicle-covering is represented by either the deltidium, the spondylium, or both.

† Mr. Schuchert includes under this family term two genera, Kutorgina and Schizopholis which have usually been regarded as belonging to the Inarticulate sub-class. The reasons for the installation of these as the elementary family of the Articulata are given elsewhere.

Family Orthidæ, Woodward.

Orthis, Dalman, 1828.
Orthambonites, Pander, 1830.
Plectorthis, Hall, 1892.
Dinorthis, Hall, 1892.
Plæsiomys, Hall, 1892.
Hebertella, Hall, 1892.
Orthostrophia, Hall, 1883.
Platystrophia, King, 1850.
Heterorthis, Hall, 1892.
Bilobites, Linné, 1775.
Dicœlosia, King, 1850.
Dalmanella, Hall, 1892.
Rhipidomella, Œhlert, 1880.
Rhipidomys, Œhlert, 1887.
Schizophoria, King, 1850.
Orthotichia, Hall, 1892.
Enteletes, Fischer de Waldheim, 1830.
Syntrielasma, Meek, 1865.

Family Strophomenidæ, King.

Orthidium, Hall, 1892.
Strophomena, Rafinesque (de Blainville), 1825.
Orthothetes, Fischer de Waldheim, 1830.
Hipparionyx, Vanuxem, 1842.
Kayserella, Hall, 1892.
Derbya, Waagen, 1884.
Meekella, White & St. John, 1868.
Streptorhynchus, King, 1872.
Triplecia, Hall, 1858.
Dicraniscus, Meek, 1872.
Mimulus, Barrande, 1879.
Streptis, Davidson, 1881.

Family Leptænidæ.

Leptæna, Dalman, 1828.
Leptagonia, McCoy, 1844.
Rafinesquina, Hall, 1892.
Stropheodonta, Hall, 1852.
Brachyprion, Shaler, 1865.
Douvillina, Œhlert, 1887.
Leptostrophia, Hall, 1892.
Pholidostrophia, Hall, 1892.
Strophonella, Hall, 1879.
Amphistrohpia, Hall, 1892.
Leptella, Hall, 1892.
Plectambonites, Pander, 1830.
Christiania, Hall, 1892.
Leptænisca, Beecher, 1890.
Davidsonia, Bouchard, 1847.

Family Chonetidæ.

Chonetes, Fischer de Waldheim, 1837.
Anoplia, Hall. 1892.
Chonetella, Waagen, 1884.
Chonetina, Krotow, 1888.
Chonostrophia. Hall, 1892.
Chonopectus, Hall, 1892.

Family Productidæ, Gray.

Strophalosia, King, 1844.
Orthothrix, Geinitz, 1847.
Leptœnalosia, King, 1845.
Daviesella, Waagen, 1884.
Aulosteges, von Helmersen, 1847.
Productella, Hall, 1867.
Productus, Hall, 1867.
Marginifera, Waagen, 1884.
Proboscidella, Œhlert, 1887.
Etheridgina, Œhlert, 1887.

Family Thecidiidæ.

Lyttonia, Waagen, 1883.
Oldhamina, Waagen, 1883.

Family Richthofeniidæ, Waagen.

Richthofenia, Waagen, 1883.

Family Billingsellidæ, Schuchert.

Billingsella,* Hall, 1892.

Family Clitambonitidæ, N. H. Winchell and Schuchert.

Protorthis, Hall, 1892.
Polytœchia, Hall, 1892.
Clitambonites, Pander, 1830.
    Pronites, Pander, 1830.
    Gonambonites, Pander, 1830.
Hemipronites, Pander, 1830.
Orthisina, d'Orbigny, 1847.
Scenidium, Hall, 1860.
    Mystrophora, Kayser, 1871.

Family Stricklandiniidæ.

Syntrophia, Hall, 1892.
Stricklandinia, Billings, 1859.

Family Camarellidæ.

Camarella, Billings, 1859.
Parastrophia, Hall, 1893.
Anastrophia, Hall, 1879.
    Brachymerus, Shaler, 1865.
(?) Branconia, Gagel, 1890.
Porambonites, Pander, 1830.
    Isorhynchus, King, 1850.
Nœtlingia, Hall, 1892.
Lycophoria, Lahusen, 1885.

Family Pentameridæ, McCoy.

Conchidium, Linné, 1753.
    Gypidia, Dalman, 1828.
    Antirhynchonella, Quenstedt, 1871.
    Zdimir, Barrande, 1879.
Pentamerus, Sowerby, 1813.
Capellinia, Hall, 1893.
Barrandella, Hall, 1893.
Sieberella, Œhlert, 1887.
Pentamerella, Hall, 1867.
Gypidula, Hall, 1867.
Amphigenia, Hall, 1867.

Order TELOTREMATA, Beecher.

Sub-order ROSTRACEA, Schuchert.

Family Rhynchonellidæ, Gray.

Protorhyncha, Hall, 1893.
Orthorhynchula, Hall, 1893.
Rhynchotrema, Hall, 1860.
Rhynchotreta, Hall, 1879.
Stenoschisma, Conrad, 1839.
Camarotœchia, Hall, 1893.
Liorhynchus, Hall, 1860.
Wilsonia, (Quenstedt) Kayser, 1871.
Uncinulus, Bayle, 1878.
Uncinulina, Bayle, 1878.
Hypothyris, (McCoy) King, 1850.
Pugnax, Hall, 1893.
Eatonia, Hall, 1857.
Cyclorhina, Hall, 1893.
Terebratuloidea, Waagen, 1883.
Rhynchopora, King, 1856.
Rhynchonella, Fischer de Waldheim, 1809.

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* The genus Billingsella, in correspondence with its early geological age, presents an elementary structural aspect indicating that it may have served as a point of departure for the Orthidæ and Strophomenidæ.

Sub-order ANCYLOBRACHIA, Gray.

Family Centronellidæ, Waagen.

Rensselæria, Hall, 1859.
Beachia, Hall, 1893.
Newberria, Hall, 1891.
Centronella, Billings, 1859.
Oriskania, Hall, 1893.
Selenella, Hall, 1893.
Romingerina, Hall, 1893.
Trigeria, Bayle, 1875.
(?) Notothyris, Waagen, 1882.
Scaphiocœlia, Whitfield, 1891.

Family Stringocephalidæ, Dall.

Stringocephalus, Defrance, 1827.

Family Terebratulidæ, Gray.

Cryptonella, Hall, 1861.
Eunella, Hall, 1893.
Harttina, Hall, 1893.
Dielasma, King, 1859.
Epithyris, King, 1850.
Cranæna, Hall, 1893.
Megalanteris, Suess, 1855.
Dielasmina, Waagen, 1882.
Hemiptychina, Waagen, 1882.
Beecheria, Hall, 1893.
(?) Cryptacanthia, White and St. John 1857.
(?) Enantiosphen, Whidborne, 1893.

Family Terebratellidæ, King.

Tropidoleptus, Hall, 1857.

Sub-order HELICOPEGMATA or SPIRIFERACEA, Waagen

Family Atrypidæ, Dall.

Hallina, N. H. Winchell and Schuchert, 1893.
Protozyga, Hall, 1893.
(?) Cyclospira, Hall, 1893.
Zygospira, Hall, 1862.
Anazyga, Davidson, 1882.
Orthonomæa, Hall, 1858.
Catazyga, Hall, 1893.
Glassia, Davidson, 1882.
Atrypina, Hall, 1893.
(?) Clintonella, Hall, 1893.
Atrypa, Dalman, 1828.
Karpinskia, Tschernyschew, 1885.
Gruenewaldtia, Tschernyschew, 1885.

Family Spiriferinidæ, Davidson.

Cyrtina, Davidson, 1858.
Spiriferina, d'Orbigny, 1847.

Family Spiriferidæ, King.

Spirifer, Sowerby, 1815.
Choristites, Fischer de Waldheim 1825.
Trigonotreta, Kœnig, 1825.
Brachythyris, McCoy, 1844.
Fusella, McCoy, 1844.
Delthyris, Dalman, 1828.
Reticularia, McCoy, 1844.
Martinia, McCoy, 1844.
Martiniopsis, Waagen, 1883.
Cyrtia, Dalman, 1828.
Syringothyris, A. Winchell, 1863.
Ambocœlia, Hall, 1860.
Metaplasia, Hall, 1893.
Verneuilia, Hall, 1893.

Family Nucleospiridæ, Davidson.

Nucleospira, Hall, 1858.
Dayia, Davidson, 1882.
Hindella, Davidson, 1882.
Whitfieldella, Hall, 1893.
Hyattella, Hall, 1893.
(?) Camarospira, Hall, 1893.

Family Cœlospiridæ.

Anoplotheca, Sandberger, 1856.
Bifida, Davidson, 1882.
Cœlospira, Hall, 1863.
Leptocœlia, Hall, 1859.
(?) Anabaia, Clarke, 1893.

Family Retziidæ.

Rhynchospira, Hall, 1859.
Homœospira, Hall, 1893.
Ptychospira, Hall, 1893.
Trematospira, Hall, 1857.
Parazyga, Hall, 1893.
Retzia, King, 1850.
Uncinella, Waagen, 1883.
Eumetria, Hall, 1864.
Acambona, White, 1862.
Hustedia, Hall, 1893.

Family Uncitidæ, Waagen.

Uncites, Defrance, 1825.

Family Meristellidæ, Waagen.

Merista, Suess, 1851.
Camarium, Hall, 1859.
Dicamara, Hall, 1893.
Meristella, Hall, 1860.
Charionella, Billings, 1861.
(?) Pentagonia, Cozzens, 1846.
Goniocœlia, Hall, 1861.

Family Athyridæ, Waagen.

Meristina, Hall, 1867.
Whitfieldia, Davidson, 1882.
Glassina, Hall, 1893.
Athyris, McCoy, 1844.
Spirigera, d'Orbigny, 1847.
Cliothyris, King, 1850.
Actinoconchus, McCoy, 1844.
Seminula, McCoy, 1844.
Spirigerella, Waagen, 1883.
Kayseria, Davidson, 1882.

Incertæ Sedis.

Eichwaldia, Billings, 1858.
Dictyonella, Hall, 1867.
Aulacorhynchus, Dittmar, 1871.
Isogramma, Meek and Worthen, 1873.

Descriptions of New Species Figured in Volume VIII, Part 2.

Orthis ? glypta, sp. nov.

(Plate lxxxiv, figs. 8, 9.)

Shell small, transverse, with long, straight hinge, making the greatest diameter of the shell; short along the median axis; marginal outline transversely subelliptical. Pedicle-valve with a broad and low median sinus and generally depressed surface. The exterior bears from twelve to sixteen low, flat plications, separated by narrow sulci, and sometimes with a fine groove on the surface of each. These extend from apex to margins, and are crossed by fine, undulating, subconcentric lines apparently in two oblique sets, producing a peculiarly reticulated or wavy surface similar to that occurring in the Swedish Silurian species, *O. Loveni*, Lindström. The muscular area of the pedicle-valve is small. Length of an average pedicle-valve, 12mm.; width, 18 mm.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Strophonella costatula, sp. nov.

(Plate lxxxiv, figs. 15, 16.)

Shell subsemicircular in outline; hinge-line straight or slightly arched; surface depressed concavo-convex.

Pedicle-valve elevated at the beak, becoming rapidly depressed anteriorly, the median depression continued on to a short lingui form extension at the anterior margin. Corresponding to this depression is a broad anterior fold on the opposite valve. The surface of both valves is covered with a few coarse, round, sharply elevated ribs, which rapidly bifuracate or multiply by implantation. These are more or less irregular or sinuous, elevated at the concentric varices and crossed by faint concentric lines.

The typical example has a length of 21 mm. and a width on the hinge of 24 mm.

Niagara group. *Louisville, Kentucky.*

Plectambonites producta, sp. nov.

(Plate lxxxiv, figs. 23–25.)

The original of this species is an internal cast of the pedicle-valve, with short, straight hinge, rather narrow, depressed umbo, the shell becoming highly convex and greatly produced anteriorly. The sides of the valve are somewhat appressed medially and the anterior margin slightly expanded, and suboval in outline. The cast shows the impression of short divergent dental plates and a moderately broad muscular impression. The width of the shell on the hinge is 10 mm.; its length, 23 mm.; its convexity from the posterior margin, 8 mm.; from the anterior margin, 28 mm.

Niagara dolomites. *Yellow Springs, Ohio.*

Spirifer crispatus, sp. nov.

(Plate xxxvi, figs. 9, 10.)

Shell small, with moderately high, incurved area, scarcely extended on the hinge, well-developed median fold and sinus, and three coarse plications on each lateral slope. The surface is covered by conspicuous concentric lamellæ.

Niagara group. *Maryland.*

Spirifer Canandaiguæ, sp. nov.

(Plate xxxvii, figs. 23, 24, 25.)

Shells of rather small size, having somewhat the aspect of an elongate and umbonate *S. fimbriatus.* Umbo of pedicle-valve prominent, narrow and closely incurved at the apex. Hinge-line quite short, cardinal small, incurved. Median sinus deep, produced on the anterior margin, its anterior width being nearly equal to the length of the hinge. On each lateral slope are from two to four low radial undulations or plications, all of which are sharply defined at the umbones. Surface covered with very fine, closely crowded concentric lines which are granulous and were originally fimbriate. Length of typical specimen, 21 mm.; greatest width, 22 mm.; length of hinge, 10 mm.

Hamilton group. *Centerfield and Canandaigua Lake, N. Y.*

Spirifer mucronatus, Conrad, var. posterus, var. nov.

(Plate xxxiv, figs. 27–31.)

A late variety of the typical Hamilton form, characterized by its small size, usually narrow bodies and acuminate cardinal extremities.

Chemung group. *Tompkins county, N. Y.*

Spirifer disjunctus, Sowerby, var. sulcifer, var. nov.

(Plate xxx, fig. 16.)

This variety is distinguished by the sharply defined median sulcus on the fold of the brachial valve. It has heretofore been embraced within the limits of *S. disjunctus*, but the character referred to appears to be persistent.

Chemung group. *Near Olean, N. Y.*

Spirifer Williamsi, sp. nov.

(Plate xxxvii, figs. 20, 21, 22.)

Shells of the form of *Spirifer increbescens*, Hall, and varying but little in size. Median fold and sinus well developed. The latter bearing usually three, sometimes four plications, finer than those on the lateral slopes. Of these the median plication is generally the strongest. This, however, is not always the case, the arrangement of these plications being frequently quite irregular. The median fold generally bears a median groove and one lateral plication on each side. On each lateral slope of the shell are seven or eight plications.

A normal example measures: Length, 15 mm.; width on hinge, 24 mm.

Chemung group. *Allegany county, N. Y.*

Spirifer Newberryi, Hall, 1883.

[See Rept. State Geologist for 1882, plate (xxxi) 56, figs. 9, 10.]

(Plate xxxi, figs. 9, 10.)

Shell moderately large, with sharp cardinal angles. Surface plication consisting of numerous fine simple or duplicate ribs which cover the median fold. On each lateral slope there are twenty-five to thirty of these plications. The plications and the grooves between them are covered with fine radiating lines.

Waverly group. *Ohio.*

Cyrtia radians, sp. nov.

(Plates xxxviii, figs. 4, 5, 50, 52; xxxix, fig. 33.)

The typical form is of medium size, with high area incurved umbo and general cyrtiniform aspect. Its outer surface is characterized by an absence of plications and fine radial striæ. Median fold and sinus well developed.

Clinton group. *Rochester, N. Y.*

An allied but larger form, here referred to this species, occurs in the Niagara dolomites, near Milwaukee, Wis.

Cyrtina umbonata, Hall, var. Alpenensis, var. nov.

(Plate xxviii, figs. 16–20.)

Cyrtina umbonata, Hall, from the original locality in Iowa, is a small shell, often obscurelv plicated; this variety possesses the contour of *C. umbonata*, but is a larger and more robust shell with broad and well-defined plications, smooth median fold and sinus.

Hamilton group. *Alpena, Michigan.*

Cyrtina lachrymosa, sp. nov.

(Plate xxviii, figs. 36, 37, 47.)

Shells small; cardinal area high, more or less incurved. Surface with low and rather narrow median fold and sinus on each side of which are two or three low, faint plications. Lateral margins of the cardinal area broadly rounded. Surface covered with elongate pustules, some coarse, but the greater number quite fine.

Height of an average specimen, 5 mm.; width and length, 6 mm.

Waverly group. *Richfield, Ohio.*

Syringothyris Missouri, sp. nov.

(Plate xxxix, figs. 29–31.)

Shell small, cyrtiniform; cardinal area high, slightly incurved toward the apex; lateral cardinal margin broadly rounded, rendering the definition of the area quite obscure. Median fold and sinus neither wide nor highly developed. Surface of both smooth. Each lateral slope with five or six low plications.

Interiorly the pedicle-valve bears strong divergent dental lamellæ which are attached to the surface of the valve for fully one-third its length. There is no median septum. The transverse delthyrial plate is thin and is developed into a delicate though distinct tube. Shell substance highly punctate on the inner laminæ. Height of original specimen, 13 mm.; cardinal width, 18 mm.; length, 15 mm.

Choteau limestone. *Choteau Springs, Missouri.*

Ambocœlia spinosa, sp. nov.

(Plate xxxix, figs. 16–18.)

Shell of rather large size, hinge-line straight, equaling the full diameter of the valve. Brachial valve depressed convex in the umbonal region, concave anteriorly, with upturned margins. Medially there is a low and indistinct elevation which disappears toward the front. Pedicle-valve not known. Surface bearing faint traces of concentric lines and covered with numerous elongate depressions which were probably bases of insertion of epidermal spinules.

Length of original specimen, 7 mm.; width on the hinge, 9 mm.

Hamilton shales. *Livonia Salt Shaft, Livingston county, N. Y.*

Seminula Rogersi, sp. nov.

(Plate xlvii, figs. 1–4.)

Shell rather small, suboval in outline. Valves subequally convex. Pedicle-valve with a low, broad median sinus and brachial valve with a corresponding fold, both becoming more distinct toward the anterior margin. Lateral slopes depressed convex. Umbones not conspicuous; deltidium concealed.

External surface smooth.

A normal individual measures 15 mm. in length, and 13 mm. in greatest width.

Pendleton sandstone (Schoharie grit). *Pendleton, Indiana.*

Athyris densa, sp. nov.

(Plate xlvi, figs. 6–12.)

Shell transversely elongate, valves compressed; median fold and sinus not conspicuously developed. Pedicle-valve shallow, with broad, sharply angled cardinal slopes, greatly thickened interiorly. The anterior margin is frequently extended into a linguate process at the termination of the median sinus. Brachial valve the more convex with an indistinct, flattened and sometimes broadly grooved median fold, with regular and even lateral slopes. In the interior of the valves the form of the muscular scars is normal, though there is a notable variation in the size of the diductor scars.

St. Louis group. *Washington county, Indiana; Colesburgh, Kentucky.*

Seminula Dawsoni, sp. nov.

(Plate xlvii, figs. 32–34.)

(See pages 95, 96.)

This species was originally identified as *Athyris subtilita* Hall, by Davidson (Quarterly Journal of the Geological Society of London, vol. XIX, 1863). Its differences from this species are indicated on the pages referred to.

Carboniferous limestone. *Windsor, Nova Scotia.*

Meristella Walcotti, sp. nov.

(Plates xliii, figs. 16, 17; xliv, figs. 6–11, 23, 32.)

Shell elongate ovate, valves convex, regular. Pedicle-valve with umbo moderately full and beak incurved; foramen generally concealed at maturity. Cardinal slopes concave and well delimited by divergent cardinal ridges. Dorsum more or less distinctly ridged in the umbonal region, broadly convex anteriorly and slightly extended on the anterior margin but with no median sinus. Brachial valve with the median elevation somewhat more strongly defined, especially in the umbonal region. Umbolateral slopes rather more abrupt than in the other valve.

Internal structure normal for the genus.

Oriskany sandstone. *Cayuga, Ontario.*

Merista Tennesseensis, sp. nov.

(Plate xlii, figs. 1–6.)

Shell subpentahedral in outline, tranverse, rarely elongate. Valves subequally convex, with broad, low fold and sinus developed on the anterior portion of the brachial and pedicle-valves respectively. Umbo of pedicle-valve not conspicuous, apex truncated at maturity by a circular foramen. Deltidial plates concealed by incurvature. Umbo of brachial valve full, apex acute. External surface smooth. Dimensions of an average example: length, 17 mm.; greatest width, 19 mm.

Upper Silurian. *Perry county, Tennessee.*

Zygospira putilla, sp. nov.

(Plate liv, figs. 35–37.)

Shell small, elongate suboval in outline. Pedicle-valve the more convex; umbo narrowed, apex acute, delthyrium inclosed. Medially this valve is elevated by a strong double plication, the parts of which diverge anteriorly, leaving a flat low depression between them, and in this lies a single faint plication. The lateral slopes are considerably depressed, and each bears from four to seven, coarse, often irregular plications, only a part of them reaching the beak.

The brachial valve is depressed convex, with a conspicuous median fold, grooved longitudiually and bounded by deep marginal depressions. The lateral slopes are more convex than on the other valve, but are similarly plicated.

Surface of the valves usually without concentric growth lines.

An average example has a length of 8 mm. and a greatest width of 7 mm.

Hudson River group. *Near Edgewood, Pike county, Missouri.*

Camarophoria rhomboidalis, sp. nov.

(Plate lxii, figs. 25–29.)

Shells of rather small size, subtriangular in outline with cardinal margins extending for half the length of the valves. Pedicle-valve with apex scarcely elevated, incurved, with deltidial plates usually concealed; slightly convex about the umbo, broadly depressed medially, forming a sinus which makes a linguiform extension on the anterior margin. This sinus may bear one and sometimes traces of two other low plications. The lateral slopes are smooth, except at the margins, where there is faint evidence of one or two plications on each. The brachial valve is convex and broadly rounded with abrupt umbo-lateral slopes, broad, low median fold, apparent only in the pallial region, and bearing a median plication. Traces of two lateral plications are visible at the margin of the valve, and these are somewhat more distinct on the surface than on the opposite valve. Surface smooth or with fine concentric lines. The interior structure of the shell is normal for this genus.

Corniferous limestone. *Cass county, Indiana.*

Parastrophia divergens, sp. nov.

(Plate lxiii, figs. 4–7.)

Shells of medium size with strongly convex brachial valve and depressed convex, anteriorly concave pedicle-valve. The beak of the pedicle-valve is erect, but not conspicuous; from the gently convex umbo the surface slopes gradually to the lateral margins, and abruptly to the front, forming a broad and deep sinus, which is sharply defined at the sides, and bears from two to four angular plications. Two or more smaller plications occur on each lateral slope.

The brachial valve is well rounded in the umbonal region, but the median fold is defined only near the anterior margin. It bears from three to five plications, with three on each lateral slope. All the plications, as well as fold and sinus, become obsolete in the umbonal region, and in old and thickened shells the latter can be distinguished only at the anterior margins of the valves.

In the interior there is a supported spondylium in the pedicle-valve, but in the brachial valve the septal plates do not unite.

Hudson River group. *Wilmington, Illinois.*

Parastrophia Greenii, sp. nov.

(Plate lxiii, figs. 17–20, 22.)

Shell robust, with convex brachial valve and shallow pedicle-valve convex in the umbonal region but concave anteriorly. Beaks not prominent; that of the pedicle-valve low but erect, that of the brachial valve full and incurved. Cardinal slopes sharply defined on pedicle-valve. Median fold and sinus on brachial and pedicle-valves not strongly defined except at the anterior margin. The brachial valve bears six broadly rounded plications which are obsolete in the umbonal region; four of these belong to the median fold, the other two to the lateral slopes. The pedicle-valve has five plications, with three in the median sinus. Interior with a median supporting septum in each valve.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Parastrophia multiplicata, sp. nov.

(Plate lxiii, figs. 15, 16, 21.)

This species differs from *P. Greenii* in its more conspicuously developed median fold and sinus, flatter and larger plications, and the greater number of the latter on the lateral slopes. The usually sessile spondylium of the brachial valve may also prove a distinguishing feature.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Parastrophia latiplicata, sp. nov.

(Plate lxiii, figs. 23–27.)

This species is distinguished from the two preceding by its smaller size, less robust form, two broad plications on the fold and one in the sinus, with but a single pair on the lateral slopes.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Liorhynchus Lesleyi, sp. nov.

(Plate lix, figs. 34–36.)

Shell of medium size with shallow pedicle-, and deep brachial valve. Median sinus on the former well defined; median fold on the latter broad and not sharply delimited. Surface of both valves sharply and abundantly plicated.

Upper Devonian. *Pennsylvania.*

Barrandella Areyi, sp nov.

(Plate lxxi, figs. 14–16.)

Shell small, ventricose, with sinus on the pedicle-valve and fold on the brachial valve. Surface on both valves rather sharply and coarsely plicated, the largest plication being in the median sinus, with traces of finer ones on the slopes of the sinus. The median fold bears two well-defined plications with faint traces of others, while on each lateral slope of the valves there are four or five less sharply angular ribs.

Clinton group. *Rochester, N. Y.*

Conchidium Greenii, sp. nov.

(Plate lxvi, figs. 20–22.)

Shell subequally biconvex, ventricose, subcircular in marginal outline. Umbones full and rounded, both incurved, that of the pedicle-valve somewhat elevated. There is no evidence of median fold and sinus. Surface of each valve bearing, over the pallial region, from forty-five to fifty rounded plications, which very gradually increase by implantation and become more numerous anteriorly. These plications are of slightly unequal size, which appears to be due to variation in the rate of their multiplication. In the umbonal regions the plications are obsolete.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Conchidium crassiplica, sp. nov.

(Plate lxvi, figs. 24, 25.)

Shell elongate, subelliptical in outline. Valves subequally convex, depressed above; cardinal slopes broad and abrupt on both. Umbo of the pedicle-valve erect, not prominent; surface slightly elevated medially. Umbo of brachial valve depressed, apex concealed; median region depressed anteriorly; surface of both valves bearing broad rounded plications, separated by deep grooves. Of these plications there are from eight to ten on each valve over the pallial region; by dichotomizing these become more numerous anteriorly.

Niagara group. *Near Louisville, Kentucky.*

Conchidium Georgiæ, sp. nov.

(Plate lxvi, figs. 18, 19.)

Pedicle-valve unknown; brachial-valve trilobed by the development of a strong median fold which extends from apex to margin, and is sharply delimited by abrupt lateral slopes. The sides of the valve are convex, rather narrow, and slope abruptly to the lateral margins. Umbo full and incurved. Surface covered with numerous duplicating plications, of which from fifteen to twenty may be counted on each side at the margins, and twelve to fourteen in the fold.

Clinton group. *Trenton, Georgia.*

Capellinia mira, sp. nov.

(Plate lxx, figs. 7–14.)

(See pages 248, 249.)

Selenella gracilis, sp. nov.

(See page 270, figs. 184–186.)

Oriskania navicella, sp. nov.

(Plate lxxix, figs. 25–27.)

(See pages 269, 270, figs. 181–183.)

Rensselæria Cayuga, sp. nov.

(Plate lxxv, figs. 1–4.)

Shell lenticular, often of large size; suboval in marginal outline. Valves subequally biconvex, sloping regularly in all directions. Apex of the pedicle-valve scarcely prominent; umbo not conspicuous, somewhat elevated medially. Divergent cardinal ridges and cardinal slopes well defined. Brachial valve with apex depressed and concealed; somewhat less convex in the umbonal region than the opposite valve. Surface of both valves covered with a great number of fine, simple, thread-like, rarely duplicating plications, of which from seventy to one hundred may be counted on each valve near the anterior margin.

Oriskany sandstone. *Cayuga, Ontario.*

Beecheria Davidsoni, sp. nov.

(Plate lxxix, figs. 36–39.)

(See page 300, fig. 224.)

Platycnemic Man in New York.

By W. H. Sherzer.

CONTENTS.

PLATYCNEMIC MAN IN NEW YORK.

(Communicated for the R port of the State Geologist.*)

W. H. Sherzer.

I. Historical.

While examining remains of prehistoric man derived from a cave upon Windmill Hill, Gibraltar, Prof. Busk and Dr. Falconer, in 1863, observed a peculiar antero-posterior flattening of the tibia. This anomaly was described some five years later before the International Congress of Prehistoric Archæology, report for 1868, page 161. One year after this discovery (May, 1864) M. Broca independently observed the same peculiarity in tibiæ derived from dolmens of Chamont and Maintenon, north-central France.† Caves, tumuli and refuse heaps in Denbighshire, north Wales, yielded similar bones in 1869 and 1871, along with a femur showing an abnormal lateral compression a few inches from each extremity. With these bones were associated those of the dog, fox, badger, pig, deer, sheep or goat, horse, water-rat, hare, rabbit, bear and eagle, which, together with a polished green-stone axe, chipped flakes of flint and crude pottery, left no doubt as to the Neolithic character of the remains.‡ This fore-and-aft flattening of the upper half of the tibia, to which the term *platycnemism* was applied, was also observed in a fragment derived from the laterite of India.

While these discoveries were being made in Wales, Mr. Henry Gillman, of Detroit, was busy exploring mounds along the southwestern shore of Lake Huron and the western banks of the St. Clair and Detroit rivers. Numerous skeletons were unearthed showing this platycnemism to a remarkable extent, the compression of the femur noted by Prof. Busk and the so-called "perforation of the humerus." This latter abnormal character is

* Read before the Geological Society of America at its Brooklyn meeting, Aug. 15, 1894.

† Mémoires sur les ossements des Eyzies. Paris, 1868. Reliquiæ Aquitanicæ, p. 97.

‡ Journal of the Ethnological Society of London. New series, vol. II, 1870, p. 440. Also, Nature. Vol. IV, 1871, p. 388.

produced by the union of the two fossæ (the coronoid and olecranon) at the elbow-joint.* These bones from the Michigan mounds were deposited with the Peabody Museum and that of Columbia College, a portion of them being described by Prof. Wyman in his Fourth and Sixth Annual Reports and in the American Journal of Science, January, 1874. These discoveries furnished Mr. Gillman with material for a number of valuable articles, which appeared from 1873 to 1880, as publications of the Smithsonian Institution, the American Association for the Advancement of Science and the Michigan Pioneer Society. Researches of the past twenty years have brought to light in various parts of the country numerous instances of tibiæ more or less flattened; more than verifying the prediction of Mr. Gillman: "I can not but believe, from what I have seen, that future investigation will extend the area in which this type of bone is predominant to the entire region of the Great Lakes, if not of the Great West." † Such bones have been reported from Wisconsin, Ohio, Illinois, Iowa, Kentucky, Tennessee and Florida; have been observed by me in the World's Fair exhibits from Missouri and New Jersey and in the Peabody collections from Massachusetts and Peru. The type is found to be of common occurrence in the prehistoric remains of Arizona, New Mexico, Mexico, Oceania and the Grand Canary Islands, associated, as in the preceding, with the perforation of the humerus. Indeed, we may now reasonably expect that these characters will be found wherever ancient remains are brought to light, the percentage of occurrences varying, more or less directly, with the antiquity. So far as I am aware this prehistoric type has not yet been reported from New York, although finds must have been far from few. While conducting a field class in geology at the Natural Science Camp, on Canandaigua lake, during the summer of 1893, a well-preserved skeleton was unearthed, which will serve as a text for the discussion of platycnemism and its associated characters.

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* By "perforation of humerus" some authors refer to the supra condyloid foramen, formed by an arch of bone just over the internal condyle, giving passage to the great nerve and artery of the forearm.

† Sixth Annual Report of the Peabody Museum, 1873, p. 19. Also, Amer. Jour. of Sci., 3rd ser., ol. vii, 1874, p. 8.

2. The Locality.

The discovery was made upon the farm of Richard M. Gage, on the east shore of Canandaigua lake, in the town of Gorham, Ontario county, about six miles south of the village of Canandaigua. The farm-house stands but a few feet to the east of the lake road, upon the edge of a small cultivated field of rolling ground, about 200 yards back from the lake and from fifteen to twenty feet above its level. This field is terminated on the south by one of the typical ravines of this region, cut out of the Hamilton shales and running back at approximately right angles to the lake shore. When the lake stood at a higher level the waters from this ravine emptied into it back at the road, near the farm-house, and the eroded material was deposited so as to give now a low flat point of land. This land yielded numerous arrow-points, celts and hammer-stones and was accordingly judged to have been the site of a former Seneca village. Just back of the residence a natural knoll rises to a further height of fifteen to eighteen feet, the soil of which consists of a stratum of brownish, gravelly clay, about a foot in thickness. Beneath this clay is a bed of fine argillaceous sand, of unknown thickness, grayish in color and distinctly stratified. This land has been in possession of the Gage family since 1836.

3. The Discoveries.

At the close of June, 1893, while harrowing over the knoll, Mr. Gage rolled out a well-preserved skull, from which, however, the upper and lower jaws had been removed. An excavation was at once made upon the eastern slope, some ten feet in diameter and two feet deep, passing into the sand. Portions of two skeletons were unearthed by Mr. Gage and his workman, lying about two feet apart and in an approximately north-east and southwest position, the heads toward the south. Their being imbedded in clay showed that an excavation had been made in the sand to the depth of a foot in order to receive the bodies. According to Mr. Gage one of these bodies had been buried upon its breast, the face turned to one side, in front of which the hands were drawn up, the left one tightly clenched. Although these hand and finger bones were well preserved, careful search did not reveal the slightest trace of the pelvic and leg bones. The skull was badly broken in being unskillfully removed, but was partially restored. The adjoining skeleton also lacked the lower extremities and the head, the skull harrowed out being supposed at the time to belong to it. The surrounding clay contained fragments of charcoal and a whitish substance, crumbling in the fingers, and resembling completely calcined bone. This material, however, rapidly dissolves in cold, dilute hydrochloric acid and consequently is adjudged to be simple calcium carbonate. Associated with these remains were bones of, at least, two ground-hogs and a foot bone of a deer, but neither implement nor ornament could be found. It seems more probable that these bodies were mutilated before burial, rather than that they were partially consumed by fire.

Some two weeks after these discoveries, in company with interested members of the Natural Science Camp, I visited the locality and enlarged the excavations. A massive lower jaw, and about a foot from it, the superior maxillaries were soon found, both perfectly fitting the original skull harrowed out by Mr. Gage. A few inches further away the neck vertebræ and upper extremities appeared and, little by little, the entire skeleton was brought out in relief from the clay matrix. Several good photographs were secured before the bones were disturbed, one of which was reproduced in the Rochester Union and Advertiser for July 29th, 1893. The body lay in a northwest and southeast position, the head toward the south, at right angles to the other bodies, some five or six feet to the west and apparently upon the same level. It had been buried upon its left side, the hands drawn up in front of the face and the thighs making an angle of about 135 degrees with the trunk. The legs were bent backward so as to form an angle of 45 degrees with the thighs, but as the pelvic bones decayed the right femur had dropped down and backward so as to be approximately parallel with the tibia.

An excavation had been made to a depth of ten to twelve inches in the sand and the body covered with clay, as in the case of the other two. How far it lay from the original surface can only be surmised, since the amount removed from the knoll by cultivation and rain erosion can not be determined. Overlying the skeleton was a stratum of clay, four to five inches in thickness, containing some charcoal being much hardened, possibly by fire, although not reddened. To the character of this stratum is undoubtedly due the excellent state of preservation of the bones. No animal remains were found with this skeleton nor any utensil, implement or ornament.

These excavations were continued a day or so later by Mr. Gage, and, guided by a dipping of the disturbed clay into the sand, he came upon a crude basin-shaped structure of hardened clay which he unfortunately destroyed, not realizing its value. From his description and an examination of the fragments removed and those still in position its general nature and method of construction were determined. Some fifteen feet to the west of the bodies a hole had been excavated to a depth of two feet in the sand, three feet from the present surface and from five to six feet in diameter at the top. This had been filled in with the surface clay and a crude, hemispherical basin shaped, having an inside measurement of three feet at the rim and a depth of sixteen to seventeen inches. The walls were four to five inches thick and reddened internally by fire to a distance of one to two inches The structure was so baked and hardened that it might easily have been removed entire by working from about it the sand and clay. It was completely filled with nearly pure charcoal, much of it oak, from limbs two to three inches in diameter. A careful examination of this charcoal failed to reveal the slightest trace of bone, pottery, implement or ornament. Just beneath the level of the rim, but to one side, were found the bones of a dog in good state of preservation. The apparent connection of this crude structure with the burials, the care with which it had been constructed, and the purity of the charcoal suggest some ceremonial use, perhaps similar to that of the so-called altars of the Ohio mounds, although it differs entirely from them in form and manner of construction. Its shape and relative proportions correspond closely with those of a stone bowl found by Mr. Moorehead in one of the Hopewell mounds, Ross county, Ohio.* Mr. Gage remembers that while setting out a vineyard, some years before, he came upon a similar mass of charcoal in this same field. Subsequently the excavations were continued westward into the

* Moorehead, Primitive Man in Ohio. Fig. xxxviii.

higher portions of the knoll. In places the sand had been disturbed to a depth of three and a half to four feet, was mixed with charcoal and the whitish calcareous substance previously referred to. Some Hamilton fossils, recent snail-shells and a small irregular fragment of burned clay were further noted.

4. Osteological Characters.

a. General.— The following brief descriptions pertain chiefly to the complete skeleton, since the comparatively few bones found of the other two were scattered before they could be obtained for careful study. This is believed to have belonged to an adult male, in middle life, whose stature, estimated in the ordinary way from the length of the femur (18.76 inches ÷ .275) was approximately five feet and eight inches. With the exception of the pelvic bones, the ribs and lower vertebræ, the bones are in excellent state of preservation, to some extent showing their original color and hardness. The larger leg and arm bones are somewhat decayed at the extremities while the more slender ones have begun to exfoliate and soften. The skull is surprisingly firm and hard. The bones throughout are massive and indicate a heavy muscular development.

b. Tibia.— In order that the most interesting peculiarities of the skeleton may be appreciated it is necessary to make some comparisons with ancient and modern tibiæ, by means of measurements, drawings and the following indices: (1) The length is taken from the tip of the spinous process, at the knee articulation, to the point of the internal malleolus at the opposite end. (2) The transverse diameter at the knee articulation. (3) The least circumference of the shaft. (4) Antero-posterior and transverse diameters, taken where the faint ridge upon the upper, posterior portion of the bone (the "popliteal line") passes obliquely down and terminates at the inner border of the bone. This is usually from one and a half to two inches below the small opening to the interior of the tibia, known as the "nutrient foramen." Some investigators take these measurements, however, at the level of this foramen. (5) The ratio of these two diameters noted under (4) obviously expresses the amount of flattening of the bone and is called the "latitudinal index." (6) Another index, the "perimetral," is obtained by dividing the least circumference by the length, and approximately expresses the *massiveness* of the bone. A table of Gillman's * is here subjoined, made up of the means from the designated localities. For purposes of comparison there have been inserted the corresponding measurements upon the left tibia of the Canandaigua skeleton, the unit used being the inch.

LOCALITY.	1. Length.	2. Trans. diam. at knee.	3 Least circumference.	4. Antero-posterior and transverse diams.	5. Latitudinal index.	6. Perimetral index.
Detroit and Rouge rivers, Mich.	14.80	2.73	2.87	1.50—.72	.486	.185
Head St. Clair river, Mich.	14.75	2.70	2.90	1.47—.80	.548	.200
Canandaigua lake, N. Y.	15.91	3.18	3.12	1.39—.81	.583	.196
Chambers island, Wis.	14.74	3.07	3.02	1.53—.90	.588	.205
Perthi-Chwareu, Wales	13.50	2.70	2.87	1.29—.79	.612	.212
Thirteen ordinary English, London	15.10	2.86	2.90	1.27—.92	.727	.195

In its length, transverse diameter at the knee and least circumference this Canandaigua tibia is seen to exceed the means of the prehistoric and modern English tibiæ. These latter were selected by Prof. Busk at random from a drawer in the College of Surgeons, London, and are assumed to represent the modern proportions. Interest attaches mainly to the degree of flattening as shown in the fifth column. At the level indicated under (4) above for measurement, the modern normal tibia shows a subtriangular cross-section and gives a latitudinal index, which may be assumed to vary from .700 to .750+. Fig. 1 shows this outline, natural size, frequently met in modern tibiæ, but giving an index of .702, very near the lower limit of the range above indicated. Fig. 2 is a reproduction of Prof. Busk's normal tibia. Both figures show three well defined surfaces existent; an external, an internal and a posterior. In platycnemic tibia the posterior surface almost completely disappears in certain types. (See Fig. 5). Fig. 3 is a similar drawing of the Canandaigua tibia, with its smooth, oval outline and index of .583. Its companion shows a still greater compression, giving an index of .560, the two averaging .571.

* Smithsonian Report for 1873, p. 378.

The degree of flattening observed in certain cases is remarkable. Fig. 4 from the cave of Cro-Magnon, France, shows one of these extreme types, which must have had an index of but little over .400. Gillman secured two specimens from the Circular mound, upon the Detroit river, with indices of .400 and .420 respectively, while one from the Grand Canaries was found by Kuhff to fall as low as .360. Expressed somewhat more intelligibly, this means that the transverse diameter but slightly exceeds one-third of the fore-and-aft diameter.

An examination of a series of flattened tibiæ shows that the platycnemism is of two varieties, depending upon whether it is

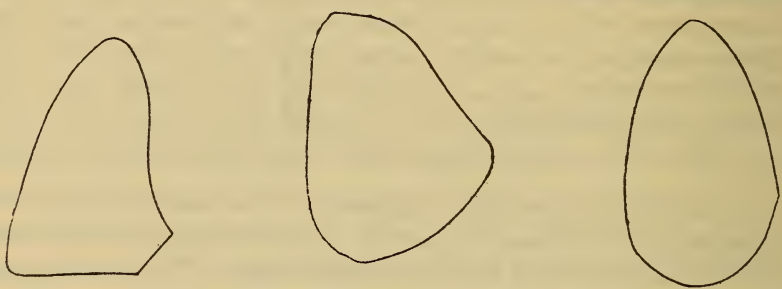

Fig. 1. Fig. 2. Fig. 3.

Explanation of Figures.

Cross-sections of tibiæ. The anterior margin is above, the posterior below, the internal surface to the left and the external, bearing the interosseus ridge, to the right.

Figures 1 and 2 represent the modern, normal proportions. Fig. 3 is the Canandaigua tibia. Fig. 4, Cro-magnon. Fig. 5, Gibraltar. Fig. 6 is from the tibia of a supposed "mound-builder."

attained by a relative extension of bone in front of or behind the interosseus ridge. If in front, we have the anterior variety, which commonly occurs in this country and in Wales; if behind this lateral, ridge we have the posterior variety; that which characterizes the Gibraltar tibiæ. Fig. 5, from Gibraltar, and Fig. 4 represent this latter type, while Figs. 3 and 6 fairly represent the anterior platycnemism.

It is usual to find associated with platycnemism a strong curvature of the body of the tibia, the convexity directed forwards, giving to the flattened bone what has been appropriately termed the "saber-like curvature." This peculiarity is, to some extent, shown by the Canandaigua tibiæ. When this curvature of the body of the tibia is absent there may still be found a backward deflection of the head of the bone, so that the axis of this head neither coincides with, nor is parallel to, the axis of the shaft, but makes with it a more or less acute angle. The result of this is that when the articulating surface of the head of the tibia is placed horizontal (its natural position when man is erect), the lower extremity of the bone is deflected backward, out of the vertical line.

c. *Femur.*—The lateral compression of the femur, first noted by Prof. Busk and described at length by Gillman,* is here observed, although to an extent that would be insignificant if not associated with other characters. This compression occurs just above the knee articulation and from one and one-half to

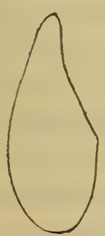

Fig. 4.

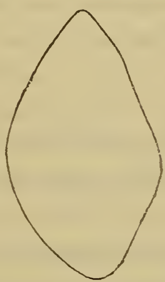

Fig. 5.

Fig. 6.

two inches below the trochanter minor. Its amount may be expressed in the form of an index, obtained by dividing the antero-posterior diameter by the transverse. In modern femora, at the indicated level below the trochanter, the outline approaches the circumference of a circle, but seems subject to considerable modification. I have found an index of .917 and one as low as .786. Gillman found a mean of .929 in a young white man, while Busk secured as the mean of three measurements an index of .783. The Denbighshire femur gave an index of .621, thus indicating considerable compression. Nineteen specimens from the Great mound upon the Detroit river showed as a maximum compression .592, a minimum of .859 and a mean of .718. Nine specimens from the Circular

* Proc. American Association for the Advancement of Science. Buffalo, 1876, p. 300.

mound gave similarly a maximum of .661, a minimum of .892 and a mean of .766. The indices for the Canandaigua femora are .772 and .764, with an average of .768, bringing them very near the mean from the Circular mound. In addition to the compression noted near each extremity the longitudinal ridge upon the posterior surface frequently becomes sharp and prominent in prehistoric femora.

d. Humerus.—The disappearance of the thin septum of bone, which separates the two fossæ at the elbow, forms the so-called "perforation of the humerus." This character has been stated to be associated commonly with those previously noted, although care must be taken to distinguish the natural from an artificial perforation. The septum, always thin, is especially liable to decay. As many as fifty-four per cent of mound and cave humeri may show this abnormality. The perforation varies much in size and it may be present upon one or both sides, occurring most frequently upon the left. In the specimen under study the right humerus shows a relatively small opening .12 by .08 inches in size. In the left, the coronoid fossa is partially filled by an abnornal deposit of bone material.

e. Skull.— This is especially characterized by heavy supra-orbital ridges, a low retreating forehead, a very prominent occiput and a massive lower jaw with teeth much worn. The length of the skull is 7.64 inches and its parietal breadth 5.43 inches, giving a latitudinal index of .711 and thus bringing it within the dolicocephalic, or long-headed type. The height is 5.98 inches, giving an altitudinal index of .783. The contents of the skull is about 95 cubic inches or 1557 cubic centimeters, a capacity considerably in excess of the means of prehistoric races and modern savages. The coronal suture is very simple and open, the sagittal near it open, but farther back becoming partially or completely obliterated. Two wormian bones occur just posterior to the mastoid processes, the larger upon the left side. The temporal ridges are not heavy but run up well toward the vertex. The entire skull seems to have much in common with the celebrated Engis skull, discovered in a cavern by Dr. Schmerling in 1833. The two have much the same contour, from whichever direction viewed, except that the Canandaigua skull has a decidedly inferior frontal development.

It is also slightly shorter and narrower, but a little higher. The molars are prominent, the extreme breadth of the zygomæ being 5.51 inches. The lower jaw, although massive, is but slightly projecting, giving but little prognathism to the skull. The teeth are heavy and much worn, even the incisors, suggesting considerable grinding activity.

A peculiar supernumerary occurs in the upper jaw, just above the first right incisor, the root projecting forward slightly and the crown passing into the enlarged anterior palatine canal.*

The second skull, found with one of the incomplete skeletons, was restored sufficiently to show that it belongs to this same type. It is rather more delicate, the supra-orbital ridges and lower jaw being less heavy, and is believed to have belonged to a female, presumably an aged one. The sutures are partially obliterated and the lower jaw contains but two shallow incisor and one canine socket.

5. Antiquity of Remains.

In the absence of utensil, implement and ornament it is difficult to assign any definite age to these remains, and this question must remain largely a matter of speculation. The state of preservation of the bones can be no criterion since this is determined by local conditions. A natural or artificial mound, in which the bones are overlaid by hardened clay, is most favorable to their preservation. There is nothing especially characteristic in the manner of burial or in the associated ceremonial fireplace. Burial upon the side was occasionally resorted to by the so-called "mound-builders" and frequently by the prehistoric eastern Indians. From such a limited amount of material no safe conclusions can be drawn from the osteological characters alone. The skulls, however, are not of the Iroquois type, being characteristically broader throughout their length and having a lower and more retreating forehead. According to Prof. Busk the platycnemism "may undoubtedly be considered a character betokening remote antiquity;"† but this is true only when known to occur in a large number of

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*Described by Dr. A. L. Benedict, of Buffalo, in the N. Y. Medical Journal, August 26, 1893 p. 228.

† Journal of the Ethnological Society of London. New ser., vol. II, 1870, p. 466.

associated remains. After a hasty examination of the skulls, Prof. F. W. Putnam, of the Peabody Museum, was inclined to refer them to the eastern Indian, with nothing to indicate a burial before or after the contact with the whites.

6. Significance of Characters.

a. Platycnemism.—The flattening of the tibia, the curvature of its shaft and head, the compression of the femur and the perforation of the humerus are "*simian* characters," in the sense that they are departures from the normal human skeleton and are normally present in the apes. A male gorilla in the College of Surgeons, London, gave for the tibiæ an index of .681, a female .650 and a chimpanzee .611. For these same apes Prof. Wyman obtained indices of .670. Hartmann found this character very marked in an adult orang. So far as our present information goes, however, no ape has ever shown any such flattening as that observed by Gillman and Kuhff; man, as remarked by Busk, having far "outsimianized the Simiæ." The theory of direct descent seems unable to explain this peculiarity in prehistoric man unless, as observed by Romanes,* we assume that the particular ancestor had tibiæ much more flattened than any existing species of ape.

M. Pruner-Bey attributed platycnemism to the *rickets*, a disease which may bring about either a fore-and-aft or a transverse flattening, but affecting only the middle and inferior portions of the tibia. The error of this view was shown by Broca, who maintained that it was a *racial character*, due to a feeble development of the calf of the leg. Hovelacque and Hervé followed Broca in assigning its cause to such feeble muscular development, relative to that of the anterior region of the leg. According to this theory the relative flattening is the result simply of a transverse thinning of the posterior portion of the bone. Topinard apparently held the view that platycnemism and the perforation of the humerus were each racial characteristics. The occurrence of these characters amongst widely different peoples at once negatives such an hypothesis.

It has been asserted to be a sex characteristic, but it is now known to occur in both sexes. Busk suggested that it

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* Darwin, and after Darwin. p. 96.

might be in some way connected with habits of foot prehension or the free movement of the foot found in savage man. A more recent French writer upon the subject, Manouvrier,* considers the flattening due to the lengthening and straightening of the posterior, external surface of the bone, that portion to which is attached the *tibialis posticus* muscle. This change he regards as brought about by a so-called *inverse* action of this muscle, as when the knee is raised from the foot firmly planted upon the ground. In his recent monograph upon the "Human bones of the Hemenway collection in the United States Army Medical Museum"† Dr. Washington Mathews accepts this explanation by Manouvrier and adds that the strengthening of this posterior tibial muscle and consequent modification of the bone may arise in three ways: First, by increasing the *distance* through which the knee is moved, as would be required in traversing a mountainous country; second, by diminishing the *time* in which the muscle can act, as in running and leaping; third, by increasing the *weight* to be lifted, as in the carrying of heavy burdens. To this latter he ascribes the probable cause of the flattening in the case of the Salado Indians.

If these factors, climbing, running, leaping and burden-carrying, could really bring about this platycnemism we should expect to find it much more commonly present in our modern Indians, but so far as known it is as rare with them as with civilized man. In the case of the kangaroo we find these same factors, *distance*, *time* and *weight* almost ideally represented, and yet, instead of a fore-and-aft flattening, the two tibial diameters are nearly equal, thus giving a relative flattening in the other direction. Another objection to the theory of Manouvrier is that it does not explain the *anterior* variety of flattening, this being the most common in this country and Wales, although not recognized as such by him.

According to this author, "This modification is not only for the purpose of furnishing to the posterior tibial muscle a surface of insertion larger and more favorably arranged. It renders the bone more resistant in the anterior and posterior direction, that is to say, in the direction in which it is not sustained by its

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* Bull. de la Soc. d'Anthropologie. Paris, 1887. 3d ser., vol. X, p. 128. Also Revue d'Anthropologie. Paris, 1889. 3d ser., vol. IV. See also Kuhff in 2d ser., vol. IV, p. 225.

† Memoirs of the National Academy of Sciences. Seventh Memoir, Washington, 1893, p. 222.

union with the fibula and in which the weight of the body, increased by the velocity of running, tends to break or bend it." Compared with modern tibia, it is true that the prolongation of bone in front of the interroseus ridge is seldom much in excess, while the backward prolongation is generally present and pronounced; still, when a series of platycnemic tibiæ is compared, one with another, the relative amount of surface, available for the insertion of muscles, in front of and behind this ridge, shows much variation. According to the view of Manouvrier those tibia, in which the character is most pronounced, should show the greatest amount of posterior prolongation, but a comparison of figures 4 and 5 shows that such is not necessarily the case. Finding this platycnemism absent in the bones of infants and children, more frequent and more pronounced in the males, but entirely absent in a large percentage of individuals, he reasoned that it must be necessarily an *acquired character.*

What seems to be a more plausible explanation has been reached by approaching the question from another direction. If found inconsistent with known facts, or those to be discovered, it has the present advantage of most satisfactorily accounting for this and other structures in early man and their later occurrences in prehistoric and modern races. We have in both man and the higher apes a group of associated characters; in addition to those discussed, the relatively greater length of the forearm, the deformation of the pelvis, the posterior position of the foramen magnum, etc. A single character in common might be considered a mere coincidence but an entire *group* of them demands some explanation. That man has descended from the apes, as we now know them, is not tenable, so that the structural peculiarities could not have been directly inherited by man from these apes. Two alternatives remain, either man has descended from an ancient man-like ape or, independently created, he has passed through a stage when he was an ape-like man. For the purposes of this paper it matters but little which the reader is disposed to accept. The similarities in structure are believed to have been brought about by corresponding similarities in life habits, and if the theory of descent (better "ascent") is accepted, these habits are believed to have been continued beyond the time when the ape received the "breath of life" and became *man.* The one common habit, capable of sufficiently reacting upon the skeleton, could have been none other than that of *tree-climbing*, after the fashion of our modern apes, the soles of the feet firmly pressed against the tree and the body held off at arm's length. The flattening of the tibia would be for the purpose of supplying, with the least expenditure of bone, additional surface for the lateral attachment of muscles producing this forcible inversion of the foot.

An inspection of the six figures shows that the surface opposite the interosseous ridge, the internal surface, remains practically unmodified in the various specimens and that the approach to the modern, normal outline is produced by the pushing out of this ridge and the straightening of the posterior surface. This is especially shown in fig. 6, taken from a supposed "Mound-builder" tibia which gives an index of .672. The significance of this is that the muscles, whose attachment we shall endeavor to locate, must have been *external*. Further, the flattening is confined to the upper half of the bone and, consequently, here must have been the main attachments of any muscles which could produce it. Obviously, muscles used in the inversion of the soles of the foot must have their tendons attached to the inner margin of the foot. Finally, in order to account for the anterior and posterior varieties of flattening, we must assume that, at least, two muscles were involved, one upon each side of the ridge, when it would be largely a matter of accident as to which gained the start of its fellow. Extra use would bring additional nutrition and growth and call for corresponding increase in bone surface. Without resorting to any knowledge, whatever, of the arrangement of the muscles of the leg, we have shown that the muscles used in the inversion of the sole and at the same time in modifying the tibia must have been attached (1) laterally; (2) externally; (3) over the upper half; (4) with tendons passing to the inner margin of the foot, and (5) there must have been, at least, two such muscles, one upon each side of the interosseous ridge. Reference to any chart, or work upon anatomy, shows that there are two strong muscles which exactly meet these requirements, namely, the anterior and posterior tibial muscles. The tendon from the former passes downward, in front of the tibia, and is attached to the base of the metatarsal supporting the great toe and to the adjacent surface of the internal cuneiform bone. The tendon of the latter passes behind the tibia, around the side of the ankle to the scaphoid, lying just behind the internal cuneiform, and giving off branches to the other ankle bones.

Note.—The method of climbing here assumed is somewhat similar to that of the linemen of telegraph and telephone companies, although with the latter the "climbers" relieve much of the muscular strain. Since this paper was read I have had an opportunity of interviewing two Western Union linemen of six to eight years' experience. One of them located the particular "tire" directly across the body of these two tibial muscles; the other across these, and also in the back part of the "calf" of the leg.

b. Perforation of humerus.— This character is of very frequent, although not constant, occurrence in the gorilla, chimpanzee and orang. It is of common occurrence in the old world monkey, but rarer in the new. It is well night constant in dogs, wolves and hyenas, but amongst the ruminants is present only in the prong-horn antelope. It is said to be constant in the wild hog, but only occasionally present in the domesticated animal. It occurs uniformly in hares and hedge-hogs, but is rare in rats and squirrels.* The perforation has not been observed outside of the mammalia. By those who have given the subject most attention it is supposed to be caused by the direct impact of the olecranon process of the ulna, in the forcible straightening of the limb. This seems especially true in the dog, in which the process extends into the opening when the limb is extended. Habits, which more or less satisfactorily explain its presence, are known in the case of most animals, in which it occurs. The arboreal habit of apes and monkeys would seemingly lead to a sufficiently forcible arm extension, except in the case of the new world monkeys, with their prehensile tails, in which forms we may suppose that the strain is less continuous and severe. An arboreal habit in primitive man would, without doubt, lead to a similiar modification of the humerus, and its absence would be much more difficult to explain than its presence. The fact that it occurs rarely in the young is not proof that it is acquired separately by each individual. The more frequent occurrence of the perforation upon the *left* side seems scarcely to admit of explanation upon any hypothesis. It occurs to me, however, that if man, as he is at present constituted, were compelled to acquire this arboreal habit, the right hand would be frequently

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* Dr. D. S. Lamb in The American Anthropologist. Vol. III, 1890, p. 159.

used for carrying and holding objects, and the strain of the bodily support would be thrown more frequently upon the left.

c. *Compression of femur, etc.* This character, together with the curvatures of the tibia, the deformation of the pelvis, the greater relative length of the forearms, the posterior position of the foramen magnum, and many (not *all*) of the other so-called "simian characters," frequently occurring in man, are to be explained upon the principle of "analogous variation." If we subject man to practically the same habits as the ape, we must expect his body to be similarly modified although, through our ignorance of environmental influences, we may be able to give no satisfactory explanation of all of these modifications.

7. Evidence of an Arboreal Habit.

a. *Comparative anatomy.*— The main evidence under this head has been presented, but it remains to explain the occurrences of these peculiar characters in ancient and modern peoples. If all races have descended from this arboreal stock these characters would be directly inherited for many generations and would abundantly appear in the ancestral stock of each branch. Changed habits, however, would slowly lead to corresponding changes in the skeleton, gradually effacing the primitive structures and leading up to what is now considered the normal type. In the case of those peoples, whose departure from the primitive type has been greatest, we should expect comparatively few "reversions." In those races which have made the least physical progress we might reasonably expect to find these ancestral characters frequently outcropping. Now, in general, it has been found that the percentage of platycnemism, of the backward deflection of the head of the tibia, and the perforation of the humerus is highest in the most ancient remains found and that it *gradually diminishes toward modern times.* In the case of the Detroit river mounds Gillman states that it was an exception to find a tibia not flattened, and whenever this occurred there was evidence of its having been of later burial.* All the tibiæ from the Gibraltar caves were stated to show this character. Mme. Cl. Royer relates once visiting M. Hamy in his laboratory

* The American Naturalist. Vol. V, 1871, p. 663.

of the *Jardin des Plantes* and finding him surrounded by an enormous mass of American bones. He remarked that platycnemism was not the *exception*, but the *rule.** Out of 100 tibiæ from Ohio, Dr. Cresson found eighteen flattened. Statistics are wanting in regard to its occurrence amongst modern peoples, but in civilized man and the American Indians it probably occurs in less than five per cent. Among the negroes it is much more common. I have examined the bones of a young negro girl which gave a mean tibial latitudinal index of .696, a femoral index of 645 and had the right humerus perforate.

In the case of the prehistoric Arizona Indians Dr. Lamb found fifty-four per cent of the humeri perforate; in the Michigan mounds they were about fifty per cent, and the Guanches from the Canary Islands gave forty-six per cent. Collections of humeri from various mounds of the United States show the perforation in from twenty to thirty-five per cent. In 156 neolithic humeri from the dolmens and grottoes about Paris it was found in twenty-one and eight-tenths per cent, while 200 Parisians from the fourth to the twelfth centuries showed the character in five and five-tenths per cent, and 218 humeri from a Parisian cemetery of the seventeenth century gave but three and two-tenths per cent. From available statistics it is believed to occur in from three to four per cent of modern civilized man and in about five per cent of our modern American Indians. In the American and African negroes the percentage may run to twenty or even thirty, being apparently quite variable.†

From the study of a limited amount of material, Fraipont found that the angle included between the axis of the head of the tibia and the axis of the shaft, had gradually diminished from 18° in the Neanderthal tibia to an average of 6.6° at the present time. In the anthropoid apes this angle averages about 25°. This backward deflection of the head of the tibia, corellated with certain characters of the femur (shape and limits of the articulating surface at the knee), proves that primitive man had habitually a, more or less, crouching posture.‡ The perfectly erect position has been slowly and gradually acquired. The same con-

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* Bull. de la Soc. d'Anthropologie de Paris, 3d ser., vol. X, 1887, p. 138.

† The American Anthropologist, Lamb. Vol. III, No. 2, p. 166; also Anthropology, Topinard. Translated by Bartley, p. 298.

‡ Revue d'Anthropologie, Paris, 3d ser., vol. iii, 1888. pp. 145–158.

clusion has been reached by Collignon who says: — "We remark, indeed, that there may be deduced from the conformationof the bone of the leg an habitual state of flexion of this member and, consequently, a gait less erect and easy than that of present man and which added to the development of the biceps and the deltoid, proven by the strong projections of their insertions, would indicate a certain aptitude for *climbing*." *

We may reasonably predict that, in future discoveries, the more ancient remains will, in general, show the greater number of cases of platycnemism and of associated characters, while these will slowly but gradually disappear from the more progressive peoples. Their persistence in the lower races seems to be due, not so much to the longer continuance of the habit, which originally induced them, but to the failure upon the part of these people to acquire other habits, which would lead to the obliteration of these characters. These occurrences above noted seem to me inexplicable upon any theory of individual acquisition, but to be exactly what is demanded by the theory of inheritance and reversion.

b. Development.— Striking corroborative evidence of man's having passed through such an arboreal stage is given by a study of fœtal and infant life. The children of such people would undoubtedly have to be assisted from the ground to the branches until they had obtained a considerable size. They could not be carried in the usual way, but would be forced to cling to the body of the parent, most naturally about the neck of the mother. The young would become adapted to such a habit, as well as to clinging to the boughs after they had been transported to the trees. This would call for special modification of the arms, hands and feet.

In a fœtus eight and one-half inches high the arms are longer than the legs, and when the body is erect the tips of the fingers reach to the knee.† At birth the arms are shorter than the legs, but still relatively longer than in the adult, and over them the infant is seen to exercise a control which it acquires over the legs only much later. The grip of a young infant is surprising and enables it, almost from the moment of birth, to support its

* Revue d'Anthropologie, Paris, 2nd ser., vol. iii, 1880, p 146.

† Huxley in "Vertebrates," pp. 417–18.

own weight. Romanes reproduces an instantaneous photograph, taken by Dr. Louis Robinson, of an infant three weeks old supporting its weight from a bough for two minutes.* Such an infant can voluntarily place the upper surface of its foot back against the leg and can readily appose the soles of the feet. It may occasionally be seen to grasp objects between the feet, strongly flexing the toes, and at times separating the great toe in a very suggestive manner. One of the strange things is that structures or characters, long since rendered nearly or quite useless, should persist almost indefinitely in the young, but this is one of the most common occurrences in the animal kingdom. It is these which the infant of to-day would naturally be expected to show rather than those characters, as platycnemism, etc., which were directly developed from climbing. These will appear, according to a recognized principle, at about the same time that they appeared in the parent.

Another evidence, which I have never seen adduced as such, is highly corroborative. The most restful and, consequently, the natural color for the eyes is *chlorophyl green.* The conclusion to be reached is the same whether we assume that the eye of man was originally created and adapted to this color or that this adaptation was slowly developed by centuries of residence in and about foliage. I can conceive of no other explanations. Such an eye is certainly not best adapted to the wants of modern civilization.

c. *Necessity of such habit.*—It may be well, before closing this paper, to inquire whether an arboreal habit would be natural or advantageous to primitive man. If we admit that there was a savage condition, before he had acquired the habit of constructing shelters strong enough to exclude the hordes of fierce and monstrous beasts, it would seem that his very existence would depend upon the acquisition of this habit. Its advantage to him in securing certain game, fruits and nuts is at once recognized. It would, undoubtedly, be systematically practiced in youth until sufficient skill was acquired. It would be partly given up as soon as man became able to cope successfully with the beasts about him, and perhaps entirely when he learned to cultivate the soil.

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* Darwin, and after Darwin, fig. 14, p. 81.

8. Summary.

It may be well to sum up in few words the views advanced in this paper:

An early savage condition of mankind when escape from terrestrial beasts and the procuring of food forced upon him an arboreal habit. Compared with our modern apes a case of analogous variation.

The abandonment of this habit and modification of the skeleton into what is now regarded as the normal type.

Direct inheritance of, or reversion to, the primitive structures.

In this way we account for the peculiarities shown in the skeleton of our Canandaigua warrior.

Note.— Through the courtesy of the librarian of the Surgeon-General's office, Washington, D. C., I have just been enabled to read the discussion which followed the presentation of Manouvrier's paper, above referred to, January 6, 1887. In this discussion I find the subject of tree-climbing came up, but was not believed by him to have been sufficiently frequent amongst Neolithic men to bring about the observed modification of the tibia. In meeting the suggestion that it might be an hereditary character, he remarked that in so attempting to explain it, the difficulty is simply pushed backward, that there still remains the explanation of how it was produced in the ancestors and that we must eventually arrive at an anatomical-physiological analysis. Such an explanation would be required only amongst those peoples in which these agencies which he considered responsible for the character had been inoperative.

A DISCUSSION

OF THE

DIFFERENT GENERA OF FENESTELLIDAE.

By George B. Simpson.

A Discussion of the Different Genera of Fenestellidae.

By GEORGE B. SIMPSON.

FENESTELLA, Miller.

This genus was first proposed in manuscript by J. S. Miller of Bristol, England, but the first published description of it was given by Mr. W. Lonsdale, F. G. S., in his description of the fossil corals, in Murchison's Silurian System (Pt. II, p. 677, 1839), as follows:

"*Fenestella*, *Miller*, *Gen. Char.* – A stony coral fixed at the base and composed of branches which unite by growth and form a cup.

Externally the branches anastomose or regularly bifurcate; internally they form a network, the intervals being generally oval.

One row of pores on each side of the branches externally, the openings being circular and projecting when perfect.

The branches, when regularly bifurcated, are connected by distant transverse processes in which no projecting pores are visible. In well-preserved specimens of the base of apparently old corals, the pores or foramina on the side of one branch have united by growth to those on the side of the adjoining branch, and constitute solid bars, either stretching transversely and simply across the intervals, or uniting obliquely three, or sometimes more together." The characters here described were illustrated on pl. 15, figs. 15 to 19, of the work cited.

In 1841 Prof. John Phillips (Palæozoic Fossils of Cornwall Devon and West Somerset) formed a new genus based upon the character of the carinae and their connecting processes.

In 1842, Prof. D. D. Owen, in Amer. Jour. Science, vol. 43, p. 19, published a figure of Le Sueur's proposed genus Archimedes, which differs from the ordinary forms of Fenestella in its spiral mode of growth.*

In 1844, Prof. McCoy (Carb. Foss. of Ireland, p. 206) proposed a new genus, Polypora, and referring to the genus Fenestella of Miller, as described by Lonsdale in 1841, says: "From Fenestella it is well distinguished by the numerous rows of pores and the absence of a keel on the interstices (branches)."

In 1845, Lonsdale (Russia and the Ural Mountains, Vol. I, appendix A, p. 629) gives the following generic characters of Fenestella:

"A ramose cellular, calcareous polypidom; cells variously distributed on one side of the branches, with or without dividing ridges; branches connected by transverse or oblique processes, cellular or not, forming generally expansions or funnel-shaped bodies; the latter with the cellular surface sometimes on the inner, sometimes on the outer side; cells cylindrical, obliquely arranged, overlying, mouths inclined outward, more or less distant; interior of mature specimens a layer of vertical capillary tubuli; reverse side of young specimens, the layer tubuli, of mature specimens, a crust perforated by minute pores; in aged specimens both cellular and reverse surfaces greatly thickened, all external ribs or sculpturing obliterated, and oval apertures more or less contracted; a row of foramina or chambers between parallelly-disposed cells, or a small cavity over the mouth in species with cells in quincunx.

In 1847, D'Orbigny proposed the genus Reteporina, consisting of species having the cellules, "placées sur deux lignes parallèles, rapprochés régulières, longitudinales, non séparées par une côte, sont á la partie superieure de branches largement anastomosées, ne manière à ne laisser entre elles que des oscules oblongs, rêguliers, placés par lignes divergentes."

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* This is probably the first published notice of the genus, and Dr. Owen remarks: "I am not sure that Le Sueur ever published a description of this fossil, but I know that when he resided here (New Harmony) he engraved a plate containing several views of it with that intention. He considers it, I believe, a new genus, but it may be only a new spec es of Retepora, if so most aptly entitled Retepora Archimedes."

In 1849, Prof. King (Publications of the Palæontographical Society, London, 2d series, vol. 3, p. 85) modifies Lonsdale's generic characters of Fenestella, as follows:

"A ramose, cellular, calcareous polypidom; cellules longitudinally distributed on one side of the branches in two or more linear series; the series separated from each other by a dividing ridge; forming generally expansions or funnel-shaped bodies," etc.

On page 38, *ut cit.*, Prof. King proposes the genus Synocladia, which is chiefly based on the character of the connecting processes, which are celluliferous and arched or angular; and, on page 40 the genus Phyllopora having wide connecting celluliferous processes or dissepiments. In his diagnosis he speaks of the branches as anastomosing. His original description and a discussion of the genus occurs further on in this paper.

In 1849, D'Orbigny proposed the new genus Archimedipora, founded upon and illustrated by the axis of Archimedes, and from a misinterpretation of its true characters. It is identical with Archimedes.

In 1857, Prof. James Hall (Proc. Amer. Ass. Adv. Science) proposed the generic name Lyropora for those flabellate forms which have their margins greatly thickened and apparently solid.

In 1858, Prout (Trans. Acad. Sci. St. Louis) proposed the name Fenestralia for a form having the general appearance of Polypora, but having four ranges of cell apertures, two on each side of a prominent median keel or carina.

In the same year and same publication he proposed the name Septopora for those forms which differ from Synocladia in having only two ranges of cell apertures.

In 1887 (Palæontology of New York, vol. VI) the following generic names were proposed:

Unitrypa for those forms having the general aspect of Fenestella, but with prominent carinæ, connected by very thin plates, called scalæ, which are sometimes expanded at the summit; noncelluliferous face solid, without pores.

Isotrypa, for those forms having the general aspect of Fenestella, but having prominent carinæ, the expanded summits of which are connected by round or oval bars, not plates as in Unitrypa. On the reverse face there are conspicuous apertures on or near the dissepiments.

Ptiloporina, for those forms which have strong primary or principal branches from which the smaller or secondary branches proceed laterally; branches with three or more ranges of cell apertures.

Ptiloporella, similar to the preceding, but having only two ranges of cell apertures.

Fenestrapora, for those forms having a prominent carina, poriferous on the summit; reverse face with numerous conspicuous pores.

Loculipora, for those forms having sinuous branches; both branches and dissepiments with prominent carinæ expanded at the summit, connecting and forming a structure closely resembling the noncelluliferous face of the frond; cell apertures arranged around the fenestrules, two being on each dissepiment.

Tectulipora, for those forms similar to the preceding, but with straight branches and with the cell apertures arranged in two parallel rows, one on each side of the carinæ.

In this paper several new genera or subgenera are proposed.

Remarks on the intimate relations of the various genera.

Though the forms included in the family Fenestellidæ must be grouped under several genera for convenience of discussion, and to facilitate the identification of species, yet they are intimately related, and there is a regular and very gradual gradation from one genus to another.

As the genera are now constituted, some of the forms might with equal propriety be included in either of two genera.

The various genera are founded mainly upon the mode of the uniting of the branches, whether by dissepiments or anastomosis; the number of ranges of cell apertures; the character of the dissepiments, whether celluliferous or not, and the character of the carinæ, which gradually change from a simple low carina to such forms as occur in Isotrypa and Loculipora.

The word "dissepiments" has been almost universally used to describe the processes connecting adjacent branches, but it would seem that some word designating their character would be more appropriate.

The dissepiments are formed at more or less regular intervals by lateral expansions from contiguous sides of adjacent branches, meeting midway between the branches and forming apparently solid bars, but this solidity is in a great measure only apparent, for a section shows that the cells occupy the greater portion of the interior of the dissepiment. In some genera intermediate cells are formed which have their apertures on the dissepiments; the dissepiments thus presenting the same appearance as the celluliferous face of the branches. Though in one case the dissepiment is apparently solid and in the other cellular, a transverse section, in a majority of cases, shows that both are cellular, varying only in the number of cells occupying the dissepiment. When the dissepiment is composed of two cells, one from the side of each adjacent branch, the walls separating the cells may be of variable thickness, though frequently not thicker than the walls separating the cells of the branches. When the dissepiments are very slender and long the deposit separating the cells may be of considerable thickness. This feature will be illustrated by the following figures:

1 2 3

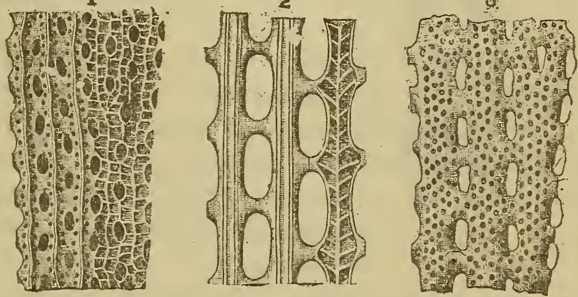


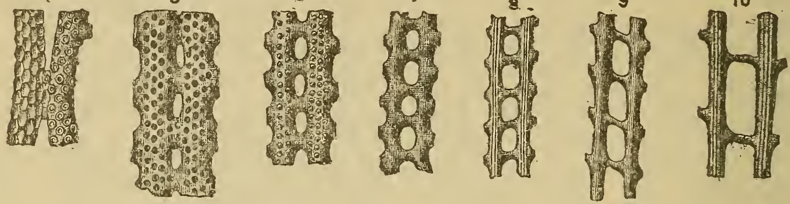
Fig. 1 is an illustration of a Fenestelloid form from the Hamilton group; the exterior showing two ranges of cell apertures separated by a median keel or carina. The branches are united by apparently solid dissepiments, but a section of the interior shows the dissepiments to be composed of cells in precisely the same manner as the branches.

Fig. 2 represents *C. paxillata* of the Lower Helderberg group, showing the lateral extension of the cells to form the dissepiments.

Fig. 3 represents *Polypora shumardi* of the Corniferous limestone and shows on the same frond both apparently solid and celluliferous dissepiments, some of the dissepiments having the characteristic features of Phyllopora and others those of Polypora

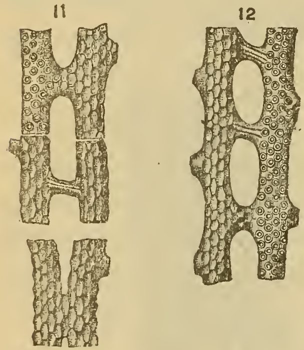
From the manner of the formation of the dissepiments it fol lows that the anastomosis of branches and connection by dissepiments is essentially one and the same thing; in fact, from different specimens a regular gradation can be observed from the anastomosing of the branches to connection by very slender dissepiments, as will be seen from the following figures:

4 5 6 7 8 9 10



In one species from the Niagara group from Waldron, Indiana, we have on the same frond both anastomosis of

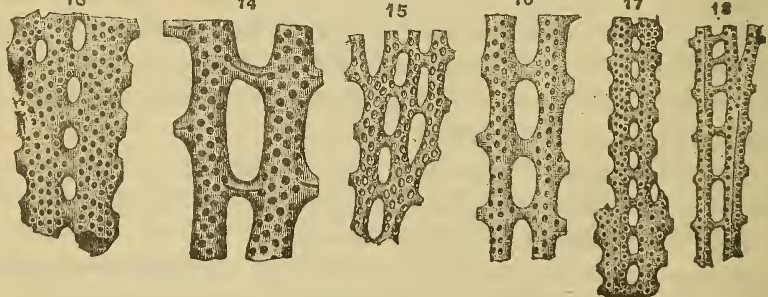
11 12



branches and connection by slender, noncelluliferous dissepiments, and also by wide celluliferous dissepiments, one specimen having on different portions of the frond the characters of Reteporella (see figs. 11 and 12), Phyllopora and Polypora.

The typical species of the genus Polypora, *McCoy*, is distinguished from the typical species of Fenestella by the numerous rows of cell apertures and the absence of a median carina. The typical species of each genus are well defined and easily distinguished from each

13 14 15 16 17 18



other, but there are numerous forms intermediate between these two extremes, and as the genera are now constituted, it is a perplexing question to which genus some of the forms belong.

Figs. 13, 14, 15, 16, 17, 18 and 19 show a regular gradation from a typical Polypora to a typical Fenestella. *Polypora lilœa* of the Lower Helderberg group has from two to four ranges of cell apertures on a branch, with the dissepiments both celluliferous and noncelluliferous.

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F. paxillata of the Upper Helderberg group (figs. 2, 10), for some distance above the bifurcations has three ranges of cell apertures, thence to the next bifurcation four ranges.

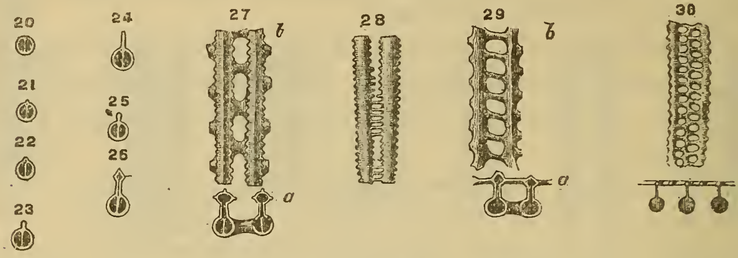
F. compacta of the Lower Helderberg group has for some distance above the bifurcations two ranges of cell apertures, with rounded interspace, followed by three ranges to the next bifurcation, and is, therefore, in neither a typical Polypora or Fenestella. In tracing these characters through several species we find the space occupied by three ranges of cell apertures becoming less until in *Fenestella Eudora* of the Lower Helderberg group there are only two ranges of cell apertures except for a short distance below the bifurcation, where there are three. The two ranges are separated by a ridge (carina). The three ranges have no separating carina. We have, therefore, in this one specimen a typical Fenestella as limited by King and a typical Polypora of McCoy. Later on I will discuss more fully the genus Polypora and related forms.

We have seen how intimately related are the forms previously considered.

If we take typical forms of Fenestella and Hemitrypa the difference is even more marked than in the previous examples; but by the examination of a large number of species we will see that the change from one form to another is just as gradual, and that in the connecting series of forms no link is missing, so that it is very difficult to fix any limit at which Fenestella ends and Hemitrypa begins. In order to elucidate this statement a series of drawings is here given, illustrating sections of branches, showing the gradual development of the parts upon which the genus Hemitrypa has been founded.

The drawings are all from accurate measurements of specimens and are in no case in the slightest degree exaggerated.

Commencing with a species having two ranges of apertures without a median keel we see a gradual change through forms with strong carinæ to the typical forms of Hemitrypa.



In fig. 20 the branches are rounded with no median keel; fig. 21 has a very slight keel; in fig. 22 the keel is slightly more elevated; in fig. 23 the keel is still more elevated, and in fig. 24 the keel is much more prominent and attenuated above; in fig. 25 the keel is slightly thickened at the summit; in fig. 26 the keel is more elevated and is laterally expanded above; in fig. 27a the keel is elevated and much expanded above, having on each margin of the expanded portion a row of minute nodes or spinule-like projections; the upper figure, b, is a view looking upon the celluliferous face of a similar form; in fig. 28 the keel is elevated and expanded above, the nodes on the margins are in some instances prolonged until those of adjacent carinæ from contiguous branches meet, coalesce, and form bars connecting the summits of adjacent carinæ.

The species from which this drawing was made is *Fenestella precursor* of the Lower Helderberg group, the same feature is shown in *F. perplexa* of the Upper Helderberg group and is still more pronounced in an undescribed species from the Hamilton group, where a portion of the frond has marginal nodes as in fig. 28, and other portions are of precisely the same character as represented in fig. 29.

In fig. 29 the keel is elevated and expanded above, and the summits of the carinæ are connected by lateral processes; looking on these from above they have the appearance of dissepiments, and they are the characteristic feature upon which is founded the genus Unitrypa.

In fig. 30 the connecting processes are not opposite to each other as in fig. 29, but alternating, meeting midway between the adjacent branches, coalescing, forming a secondary ridge or pseudo-carina, giving the typical form of Hemitrypa of Phillips.

From fig. 29, Unitrypa, there is a departure in another direction and a gradual change to Loculipora.

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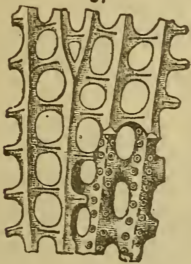

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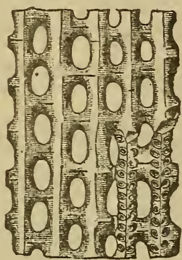

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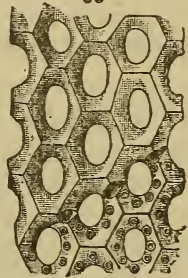

In fig. 31 the processes connecting the summits of the carinæ are stronger and more distant.

In fig. 32 the carinæ and connecting processes are very much thickened and present the appearance of the non-celluliferous face of a frond; on removing this portion of the frond the cell apertures become exposed, as shown in the lower right-hand corner of the figure.

In fig. 33 both the branches and dissepiments are carinated, the carinæ very much thickened and expanded above, presenting the same appearance as the non-celluliferous face of the frond. There is even a more gradual passage from one form to the other than is here represented, but the illustrations are sufficient to show the gradual development of the different characters.

If the more complex forms occurred in the later formations and the simpler in the earlier, it would be a beautiful illustration of evolution, but unfortunately for that illustration the different forms occur at the same time, the most simple and complex being frequently found on the same slab of stone.

Hemitrypa, Unitrypa and Tectulipora all occur in the Lower Helderberg group. In the Upper Helderberg group, more frequently than in any other, as far as observed, there occur forms both flabellate and infundibuliform, in which some of the branches are much larger than the others; the ordinary branches proceeding laterally from the larger ones, precisely as the lateral branches proceed from the main stem of Ptilopora. No specimens have so far been observed showing a gradual change from these forms to Ptilopora, but from the facts as shown by other forms it is reasonable to infer that such forms have existed and will in time be discovered.

The genus Archimedes shows a more radical departure in its mode of growth from the ordinary forms of Fenestella. It has a spiral mode of growth, the central portion becoming thickened, and forming an apparently solid axis, being analogous to the columella of a univalve shell.

In some species of Fenestellidæ from the Corniferous limestone of the Falls of the Ohio, there is a tendency to a semi-spiral growth, and in 1883, Prof. E. W. Claypole proposed the name Helicopora for a form of the family Fenestellidæ in which one margin is thickened and contracted in growth by excessive secretion and deposition of calcareous matter, leaving the opposite margin to increase more rapidly and causing the frond to assume the appearance of an incipient spiral growth.

This form is very interesting as it is intermediate between the forms mentioned above from the Corniferous limestone and Archimedes.

More intermediate forms showing a gradual change will probably be discovered.

Remarks on the Various Genera.

The various definitions of the genus Fenestella by Lonsdale in 1839, the same author in 1845 and by King in 1849 have already been given in full.

After careful restudy of the subject the following description for the genus Fenestella is now offered:

A ramose calcareous bryozoan forming cup-shaped or funnel-shaped expansions; branches bifurcating and connected by apparently solid dissepiments; apertures arranged in two parallel rows on one face of the branch, separated by a row of nodes or a carina.

The carinæ vary greatly in character and appearance, and it has been with me a question whether or not such variation is of sub-generic importance.

Many species can be very naturally arranged in groups from the character of the separating nodes or carinæ. In the sixth volume of the Palæontology of the State of New York the Fenestellidæ have been described under four groups as follows: Those,

First, in which the ranges of apertures are separated by a row of nodes, or a low carina with a row of nodes on the summit (figs. 34, 35).

Second, in which the ranges of cell apertures are separated by a smooth carina.

Third, in which the ranges of apertures are separated by a prominent carina, which at about half its height is expanded, then contracted, the portion above the expansion being of the same thickness as the portion below. On the margin of the expanded portion there are usually small conical nodes (figs. 36, 37).

Fourth, in which the ranges of apertures are separated by a prominent carina, expanded at the summit; margins of these expanded portions smooth (figs. 38–41).

To these, two other groups may be added, one where the carina is very prominent, more or less expanded at the summit and with lateral nodes; the other with a very prominent carina, of the same thickness throughout, not expanded either midway of their height or at the summit (figs. 42, 43).

At first thought the character of the carinæ may not seem of much importance, but when we reflect that several genera are founded upon the character of the carinæ or structure above the celluliferous face of the branches the subject becomes of more importance.

The genera Hemitrypa, Unitrypa, Tectuliporella, Tectulipora and Loculipora are essentially founded upon the character of the carinæ, the first four being based upon the character of the lateral processes of the carinæ and the remaining two chiefly on the carinæ of the dissepiments.

There can be no arbitrary rule fixing characters of generic importance. It has always been the case and will probably always continue to be, that what one person considers to be of generic importance another will consider to be of only specific importance. In fact it seems to be a favorite pastime of some writers to destroy the genera of others solely to erect other genera from the ruins.

I do not claim that the characters mentioned are of generic importance, but one thing is certain, nearly every species of

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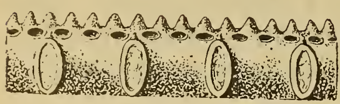

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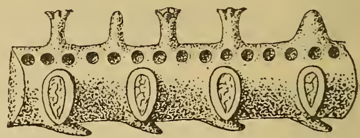

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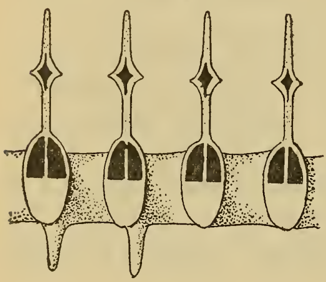

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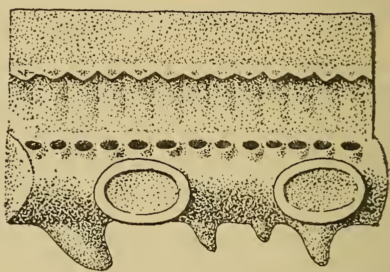

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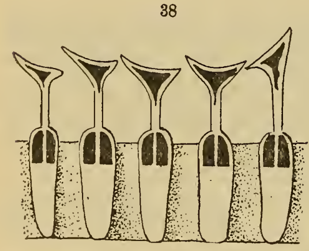

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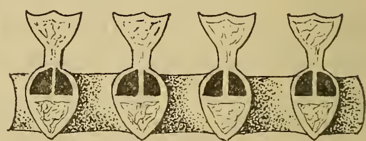

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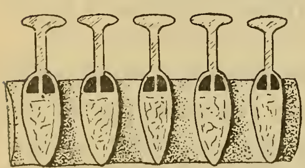

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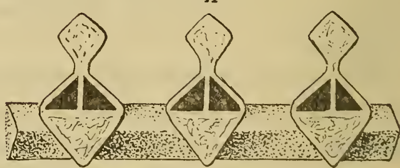

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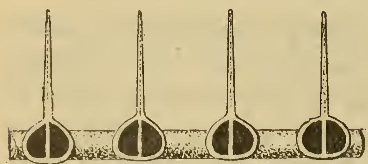

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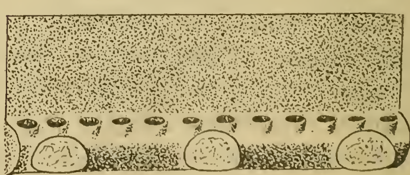

Fenestella naturally falls into some one of these six groups, and I propose to place them in these groups and name the groups.

It will certainly be of advantage to the student in the identification of species. The names of course refer to the character of the carinæ:

Group α. Fenestella (humilis), with low smooth carinæ.
Group β. Fenestella (nodata), with nodes or low nodose carinæ.
Group γ. Fenestella (laminata), with very prominent, equal, thin carinæ.
Group δ. Fenestella (mediadilata), with carinæ expanding midway then contracting, the expanded portion having nodes on their margin.
Group ε. Fenestella (summidilata), with prominent carinæ summits expanded, margins smooth.
Group ϑ. Fenestella (prætexta), with prominent carinæ expanded at the summit, margins nodose.

POLYPORA, McCoy.

The genus Polypora was founded by McCoy, 1845 (Carb. Foss. of Ireland, p. 206); ety. πολυς many and πορος pore, having a zoarium like that of Fenestella, but no median ridge or carinæ on the celluliferous face of the branches, and with three or more ranges of cell apertures.

The typical forms of Fenestella and Polypora are characteristic and very easily distinguished, but there are many forms which combine the characters of both genera, having on some branches, or on portions of them, two ranges of cell apertures, while on other branches, or on the wider portions of the same branch, three or more ranges of apertures occur, for example, in *F. paxillata* and *F. Eudora* of the Lower Helderberg group. As the genera are now constituted, it is simply a question of individual opinion as to which genus these forms belong; their characters agreeing equally well with either. Others have met with the same difficulty in classifying species.

Prof. Claypole, Geol. Mag., says: "As Palæontology advances we continually find new forms filling the gaps between others already known, and such connecting links may with justice be referred to either of the two genera which they connect. Such cases are constantly occurring and must be expected to occur yet more frequently in the future."

Mr. G. W. Shrubsole, in his paper on "British Upper Silurian Fenestellidæ," says: "As to the question whether *Fenestella intermedia* ought also to be included in the genus Polypora it may fairly be left open for consideration. It may be, and is, difficult in practice to draw the line where Fenestella ends and Polypora begins."

Mr. E. O. Ulrich, in the Palæontology of Illinois, Vol. 8, p. 358, mentions several species which could with equal propriety be included in either genus, or to speak more accurately, in either the family Fenestellidæ or Polyporidæ as proposed by Vine, which amounts to the same thing. Other quotations could be made, but it is unnecessary.

It remains then to reject altogether the genus Polypora or to form another genus which shall include those forms intermediate between Fenestella and Polypora. To me the latter course seems preferable. To place all the forms hitherto included in the two genera in one genus would make that genus unwieldy and add greatly to the difficulty of the identification of species, while it seems absurd to have two genera, either of which would, with equal propriety, include many species.

The name *Polyporella* is therefore proposed to include those species which are intermediate between Fenestella and Polypora and which have on some portions of the branches only two ranges of cell apertures and on other portions three or more ranges. The *Polyporella fistulata* of the Hamilton group is taken as the type of the genus or sub-genus as it may be considered.

The advantages of this arrangement are that by it the limits of the genera Fenestella and Polypora in regard to each other are definitely fixed and there can be no donbt as to the disposal of intermediate forms.

Such forms as *C. Eudora* of the Lower Helderberg group, which, with the exception of a small fractional space, before bifurcation, has only two ranges of cell apertures, separated by a carina, I should unhesitatingly place in Fenestella, and similarly those forms which have, except for a very small space above a bifurcation, three or more ranges of cell-apertures would be placed under Polypora, but those species in which the proportion of two and three ranges are more nearly equal I should place in Polyporella.

In recognizing Polypora to be consistent several new genera must be formed, for in Reteporella, Lyropora, Archimedes and other genera there are forms differing from each other in exactly the same manner as do Fenestella and Polypora; that is, some forms have two ranges of cell apertures, while others have three or more. Those forms with only two ranges of apertures have usually a median carina, but sometimes only a median row of nodes.

The typical species *Lyropora lyra*, Hall, 1857 (Proc. Amer. Assoc. Ad. Sci.) has three ranges of cell apertures and, therefore, corresponds to Polypora. For those forms having only two ranges of cell apertures, corresponding to Fenestella, I propose the name Lyroporella.

The typical species of Archimedes, *Retepora Archimedes*, Le Sueur, 1842, Amer. Jour. Science, vol. 43, p. 19, has only two ranges of cell apertures. To those forms having three or more ranges of apertures it is proposed to apply the name Archimedipora, D'Orbigny, (Prod. de Pal. t. 1., p. 102) which has been considered a synonym for Archimedes.

Reteporella and Reteporina differ in the same manner as do also Ptiloporina and Ptiloporella.

Erecting these genera will make uniform the practice of separating the forms having three or more ranges of apertures from those which have only two ranges of cell apertures, usually separated by a carina. If species analogous to Polyporella are found new sub-genera should be formed in accordance.

Though this multiplicity of genera or sub-genera may at first view seem cumbersome, it will on further study be found to really add simplicity to the arrangement of genera and will greatly aid in the easy identification of species.

FENESTRAPORA, Hall.

(See Pal. N. Y., vol. VI, pl. lxvi, figs. 34–39.)

This plate with several others in the volume has been badly printed, but a faint idea of the appearance of the genus may be obtained from the illustrations.

This genus was found to include those species having a carina expanded at the summit, with a row of pores on the expanded portion. On the non-celluliferous face there are numerous conspicuous pores with elevated peristomes, triangular, circular or rhomboidal.

In the type-species the pores on the summit of the carinæ show plainly. In other forms I have been unable to discover these pores, but it may have been owing to the condition of the specimens.

RETEPORELLA, nov. gen.

The name Retepora has been applied to those forms of Fenestellidæ, of which the branches anastomose at regular intervals, forming oval or lenticular fenestrules and having on the celluliferous face three or more ranges of cell apertures. The name Retepora was first given by Lamarck to recent forms, which differ generically from those above described. For these fossil forms the name Reteporella is proposed. They differ from Reteporina of D'Orbigny in the same manner as Polypora differs from Fenestella, i. e., in having three or more ranges of cell apertures.

The genus Reteporina was founded by D'Orbigny in 1847 to include those species of Fenestellidæ having the cellules "placées sur deux lignes parallès, rapprochés régulières, longitudinales, non séparées par une côte sont à la partie superieure de branches largement anastomosées, de manière a ne laisser entre elles que de oscules oblonges réguliers placés par lignes divergentes."

D'Orbigny did not illustrate his genus, and it is possible that the specimen would show that I have misunderstood his description. He says that the rows of apertures are not separated by a ridge, but the presence or absence of such a ridge does not make a generic difference, though, as already shown, species may be placed in different groups of the same genus from the character of the carinæ.

The idea I have formed from D'Orbigny's description is that of a fenestelloid form whose branches are sinuous and anastomosing, having two ranges of cell apertures on the celluliferous face, a good example of the genus being *Reteporina striata* of the Hamilton group. (Annual Report of the State Museum for 1886, pl. iii, figs. 1–6.)

In Reteporella the branches anastomose, as is shown by the fact that when the branches are in contact (anastomosed) the number of ranges of cell apertures is just twice as great as on other portions of the branches, an interstitial series never occurring. The ranges of apertures simply approach and recede from each other on account of the sinuosity of the branches.

Flat Forms.

There are two modes of growth, flabellate and infundibuliform. In a very extended observation I have never seen the same species assume both of these forms, and it is fair to infer that the same species has always the same mode of growth, that is, it is uniformly flabellate, or uniformly infundibuliform.

As by this mode of growth all species of *Fenestella* naturally form two groups, it seems to me that they are worthy of generic distinction.

The typical species of Fenestella are infundibuliform. For those species which in other respects are the same as Fenestella, but which have a flabellate growth, I propose the name Flabelliporina.

For those species which in other respects are the same as Polypora, but have a flabellate mode of growth, I propose the name Flabelliporella.

To me it seems that the marked difference in the mode of growth as is exhibited by the fan-shaped and cup-shaped forms is of a higher generic importance than the difference in the number of rows of cell apertures on a branch or the height and shape of the carinæ, both of which features have been deemed of generic value.

The genera Lyropora, Archimedes, Helicopora and Ptilopora have all been formed on the mode of growth. It may be objected that by a fragment alone it can not be determined whether a species is flabellate or infundibuliform, but neither can it be determined from a fragment whether it belongs to Fenestella, Lyropora or Archimedes. In all these genera it is necessary to have a characteristic portion of the frond in order to determine the genus.

PTILOPORELLA, Hall.

(See Pal. N. Y., vol. VI, pl. xliii, figs. 7–9.)

In 1874, H. A. Nicholson (Pal. Ohio, vol. 2, p. 264, pl. xxv, figs. 11, 11a) described a peculiar fenestelloid form from the Niagara group as *Fenestella nervata.*

Forms of this particular mode of growth do not, so far as I know, again occur until the Upper Helderberg formation is reached.

The peculiarity of this form is the method of branching. In the ordinary fenestelloid form the branches are of essentially the same size and increase by bifurcation. In this form there are a number of prominent or main branches, from which smaller branches proceed laterally, either from one or both sides. At intervals one of the lateral branches increases in size and becomes one of the main branches, having lateral branches in the same manner as the primary main branches. This method of growth is repeated as long as the expansion of the frond continues.

As is the case in all other forms of Fenestellidæ some of the species have only two ranges of cells on a branch while others have three or more.

Those forms which have only two ranges of cell apertures have been placed in the genus Ptiloporina.

Those which have three or more ranges of cell apertures have been placed in the genus Ptiloporella, the latter genus having the same relation to the former as Polypora has to Fenestella. The typical species are represented on plate xliii.

Both of these genera are infundibuliform. There are other species which always have a flabellate growth, and the lateral arrangement of the secondary branches is even more pronounced than in the infundibuliform fronds. If one of the main branches with its lateral branches is broken away from the main frond the fragment has precisely the appearance as a fragment of Ptilopora.

Following the same process of reasoning by which the genera Flabelliporella and Flabelliporina have been formed I propose to separate these flabellate species from the infundibuliform and the term Pinnaporella may be applied to them.

The forms observed have three ranges of cell apertures. Others will undoubtedly occur which have but two ranges of cell apertures and for these the generic name Pinnaporina is suggested.

SEMICOSCINIUM, Prout.

(Prout, Trans. Acad. St. Louis, 1858, p. 443, pl. 17, figs. 1–1f.)

"Bryozoum, a leaf-like expansion, somewhat penniform, without a shaft; sole formed of longitudinal and parallel ridges, sur-

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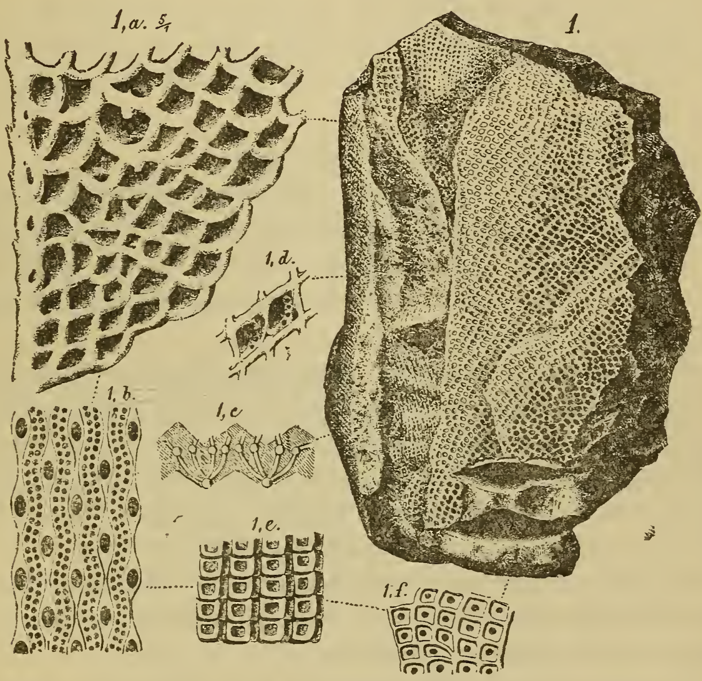

mounted by a cellular tissue, divided perpendicularly by thin longitudinal septa, corresponding to the ridges and supporting parallel lines of moderately large tortuous tubes, alternately approximating and receding from each other; covered by a dense stony crust, divided into a more or less regular net-work, representing irregular longitudinal rays (obliquely lateral here), and dissepiments, which bound rhomboidal or oval fenestrules, giving passage to cells originating in the cellular tissue of the sole, and from the sides of the tortuous tubes, all of which cells come to the surface in a direction obliquely upward and outward to the plane of expansion. The tortuous tubes alternately approximate and diverge, so as to give place to quincuncial oval openings, forming a part of the fenestrules which have their origin in the cellular substance of the sole; each tortuous tube has a line of cell pores on each side, which find their way through the fenestrules to surround a central stylus of cell pores, which seem to have had their origin in the cellular tissue of the *sole* at the bottom of the deep fenestrules."

Mr. Prout misunderstood the character of the specimen, and the description is worthless. It is only when we see the illustrations that we can form any idea of the real character of the fossil described.

Ulrich, Geol. Ill. vol. VIII, p. 555, says:

"On account of certain very unfortunate errors in Prout's original diagnosis of this genus, the name has not become current. His type specimen was, however, almost beyond question, a fragment of a large and easily recognized species which is common at the Falls of the Ohio.

"He mistook the obverse for the reverse side, and described the thin membrane which is often drawn over the summits of the high carinæ, as a longitudinally lined sole. The spaces between the branches and this membrane is filled with vesicular tissue. This he noticed and described, together with the true zooecia, which he called 'tortuous tubes,' as a part of the 'sole.'

"The cells, he supposed, originated in the tortuous tubes and opened into the fenestrules. In short his conception of *S. rhomboideum* was altogether incorrect.

"The genus as now defined departs from Fenestella in having the keel very much higher and expanded at the summit, and the branches zigzag on the reverse. The zoarium is always infundibuliform, with the inner side non-celluliferous.

"Species of this genus can be recognized in the Niagara group, but it is not until we reach the Upper Helderberg rocks that they assume their most marked peculiarities and become abundant.

"Here we find nineteen species, the majority of which have been described by Prof. Hall under Fenestella. Seven more species are described by that author from the Hamilton group.*

"Above this horizon the genus is not known."

To me it seems scarcely credible that Mr. Prout, who had described several species of Fenestella and who had proposed two new genera of Fenestellidæ, and who in his descriptions and remarks showed that he understood the subject, should be so greatly at fault in describing a form which differed from others which he had described only in having a prominent keel or carina expanded at the summit, especially as in his descriptions he almost invariably describes the keel, its height and general appearance.

After carefully reading his description and examining the illustrations, which are of much more importance, I am fully satisfied that he had before him some form of Unitrypa, evidently the first that he had seen, and the characters of which, in the poor condition of the only specimen observed by him, might easily be misleading to him.

Admitting Mr. Prout to have been describing a Unitrypa his description becomes intelligible, which it would not be if he were describing a form of Fenestella with prominent carinæ.

If his fig. 1 is closely examined the larger portion of the figure will be seen to be a very good illustration of the summits of the carinæ and connecting scalæ of a Unitrypa, while in the upper left-hand portion of the figure this portion is broken away and the branches below are shown. Fig. 1a is somewhat mystifying, especially the solidified margin at the left of the figure and also the title "fenestrules enlarged." Fig. 1b is an illustration of worn branches and would serve equally well for a Unitrypa or a Fenestella. Fig. 1c is ideal and incorrect; 1d is also ideal and is not correct, yet shows that the cell apertures and consequently the branches occurred beneath another structure, which I maintain was the summits of the carinæ and their connecting scalæ, but fig. 1e, "terraced appearance of cells broken off near

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* In this statement Mr. Ulrich is mistaken, as twenty-six species with "prominent carinæ expanded at the summit" were not described by Prof. Hall under Fenestella or under any other genus.

sole," is the convincing figure, even more than fig. 1, which without supporting evidence, shows clearly the character of the fossil. Frequently when a Unitrypa is imbedded in a rock the substance of the fossil is dissolved away, leaving a mold. When the mold of the summits of the carinæ and connecting processes are broken away it leaves in the rock a structure of which fig. 1e is an absolutely correct illustration. I give here a figure made by myself from *Unitrypa lata* for comparison and to show that Prout's fig. 1e illustrates the same character. That the fossil or portions of it were in this condition is shown by Mr. Prout's own words: "This interesting fossil was imbedded in a very refractory rock and was so much weather-worn and the fenestrules so filled with foreign matter that it was only after a laborious investigation that we were enabled to obtain anything approaching a definite view of its organization. * * * The great diversity of form, presented in its complex organization under the influence of different degrees of weathering, rendered it often very difficult to determine whether we had under our observation some modification of normal development or some alteration by atmospheric influences."

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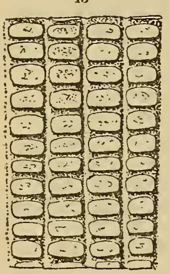

Figs. 1 and 1e are very good figures indeed of the characters on which are founded the genus Unitrypa, and I do not see how the figures could have been made from any other form.

The first name given to a genus can not, of course, be changed, and to the author first describing it the credit should be given, but as in this case it is a matter of dispute as to what form was described, the name Unitrypa will probably stand unless the specimen from which Prout's original description was made can be found. In the latter case I have little doubt that it will prove to be *Unitrypa lata*.

UNITRYPA, Hall.

(See Pal. N. Y., vol. VI, pls. li and liii.)

We have seen in a former part of this article how gradual is the change from those forms of Fenestella having two ranges of cell apertures separated by a row of nodes along the middle of the branch to the genus now under discussion.

This genus differs from the typical Fenestella as follows: The carina is always very prominent, being frequently equal in height to twice the thickness of the branches or even more. For a short distance above the branches, generally for about one-third or one-fourth of its height, the carina is very thin; it then becomes thickened and continues of essentially the same width to the summit. The thickened portion is usually a little more than twice the width of the thinner portion, rarely more. The carinæ are connected by thin, usually oblique plates, called scalæ, which extend the whole height of the thickened portion of the carinæ. In some species the entire plate is oblique to the axis of the branches in one direction (fig. 46); in others the plate is abruptly bent at about half of its height, so that the upper half of the scalæ is oblique to the branch in an opposite direction of the lower (figs. 47, 48.)

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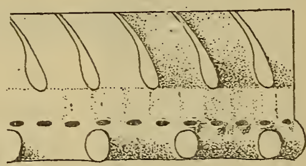

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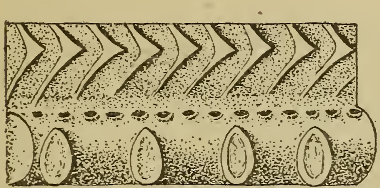

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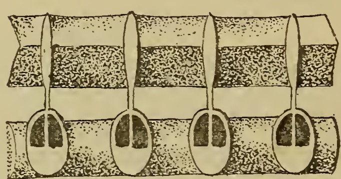

In these cases the lower portion of the scalæ is very thin, the upper portion being two or three times the thickness of the lower. In those cases where the scalæ are not bent, the lower portion or base is the thickest, gradually growing less to the summit, which is very thin.

The scalæ frequently correspond in number to the cell apertures, but this may be only accident, as in other cases the cell apertures are from two to four times as numerous as the scalæ.

In a superficial examination it might seem that the generic characters of Unitrypa and Isotrypa were the same, but in reality they are very different.

In Isotrypa the summits only of the carinæ are connected by bars, which do not extend upon the sides of the carinæ.

In *Isotrypa conjunctiva* and *Unitrypa pernodosa* the connecting processes are at about the same distance apart, but there is no similarity in the appearance of the fronds as would be the

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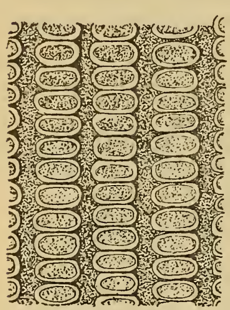

case if they were of the same genera; on the contrary, the fronds are very dissimilar in appearance. The carinæ and connecting processes of Isotrypa resemble in a very marked degree the noncelluliferous face of some fenestelloid form; while in *U. pernodosa* they have the appearance of the mouths of large oblique cells. Sometimes the summits of the carinæ are not continuous, and that surface of the frond has very much the appearance of some forms of Alveolites.

If the unitrypic face of a frond be ground down a little it will be seen that each carina and scala consists of two thin plates united at the summit. In a section the unitrypic character would seem to be due to a series of tubes in contact or nearly so, and coalescing at the summit. This feature is illustrated in figure 49.

HEMITRYPA, Phillips.

In 1841, Prof. John Phillips (Palæozoic Fossils of Cornwall, Devon and West Somerset) formed the germs Hemitrypa. ("Ety. = ημισως, half τρυπα, perforation "), one species of which, *Hemitrypa oculata* (p. 27, pl. 13, fig. 38,) he describes as follows:

"Character, a thin lamina of coral expanded in a cup form mass; external surface wholly covered with numerous round pores or cells, radiating from a center and associated in double rows which near the center undergo frequent divisions so as to form two such (double) rows. Internal surface marked by radiating ridges corresponding to the external interstices between the rows; between these ridges are many oval depressions, *which penetrate only half through the substance of the coral, and nowhere reach the outer face.*

"It grows to the size of two or three inches in diameter. The internal face is like that of some Fenestella, but the peculiarities of the external surface seem to demand generic separation. The specimens are extremely perfect."

The description is somewhat vague, but the illustrations show it to have precisely the characters of the form described as *Hemitrypa biserialis*, Lower Helderberg Group, Pal. N. Y.,

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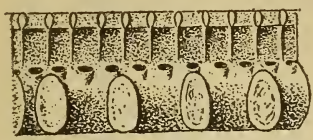

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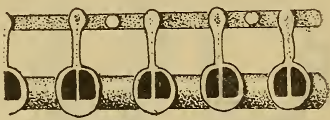

vol. VI, pl. xxii, figs. 13–18, *Hemitrypa columellata*, Upper Helderberg Group, *Hemitrypa cribosa*, Hamilton Group, etc.

The characters of the carinæ are illustrated in figures 50, 51.

CYCLOPORINA, nov. gen.

(See Pal. N. Y., vol. VI, pl. xlix, figs. 12–21, and Ann. Rep.)

In the Upper Helderberg and Hamilton groups are certain forms of Fenestellidæ, the branches of which on the non-celluliferous face are more or less regularly zigzag and anastomosing, and on the celluliferous face have prominent carinæ, from which proceed lateral semi-circular projections.

These have hitherto been included in the genus Fenestella, but I think the peculiarities of their structure are of sufficient importance to justify placing them in a separate genus. They are illustrated in vol. VI, Pal. N. Y., pl. xlix, figs. 11–12, and in the annual report of the State Geologist for 1886, p. 55, pl. vii, figs. 12–15. Two separate species have been included under one name in the report, figs. 12, 15 and 16, being *C. hemicycla*, and figs. 13 and 14 are of another species. Though *C. rhomboidea* was first described, *Cycloporina hemicycla* is much more characteristic, and for that reason I shall make it the type species of the genus. It is represented by figure 52.

On the non-celluliferous face the branches regularly anastomose, and that face of the frond resembles very closely the non-celluliferous face of *Reteporina striata* and *Reteporella retiformis*, it being almost or quite impossible to distinguish the species by that face of the frond. On the celluliferous face the carina is thin, not nodose, slightly elevated and having thick semi-circular, lateral projections which extend about half the distance to the adjacent carinæ. When the projections of adjacent carinæ occur opposite to each other they frequently coalesce, forming a con-

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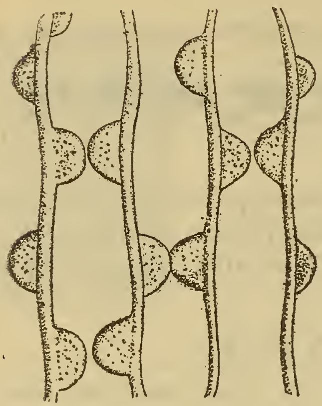

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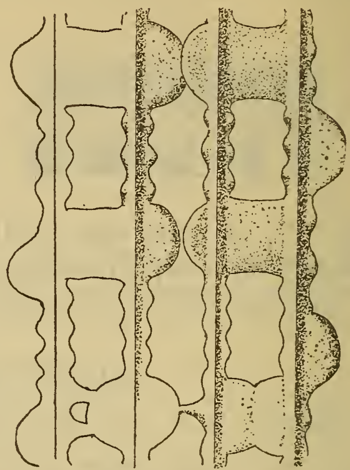

tinuous plate uniting the two carinæ. The projections occur at irregular intervals but always over a dissepiment.

The carinæ of *Cycloporina rhomboidea* differ decidedly from *C. hemicycla*, anad correspond to groups of Fenestella. They are thin, very prominent, expanding at about midway of their height, then contracting, the upper portion being of the same thickness as the lower. On the margin of the expanded portion is a row of nodes corresponding in number to the cell apertures and alternating with them; immediately below the nodes and alternating with them is a row of small circular pores. The sides of the carinæ have perpendicular grooves opposite the cell apertures.

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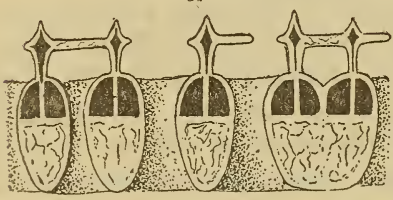

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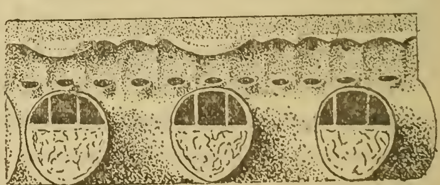

The semi-circular projections are more numerous than in *C. hemicycla* and the opposite ones are more frequently united; the fronds sometimes presenting a Unitrypa-like appearance. The characteristic features of this species are represented in figures 53–55. Figure 58 is from the carina of an undescribed species.

The species in which the carinæ vary in the same manner as the groups of Fenestella discussed in a former portion of this

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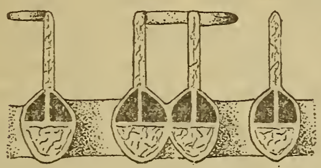

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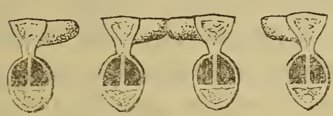

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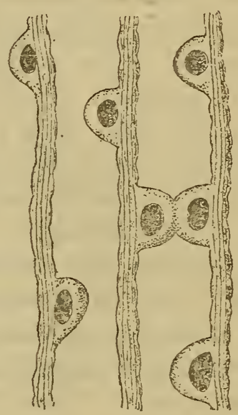


paper, may, in similar manner, be designated by letters of the Greek alphabet.

Group α; with a thin, slightly elevated carina (fig. 52.)
Group β; with low nodose carina.
Group γ; with the prominent carina, equal thickness throughout (fig. 56.)
Group δ; with carina expanded midway of the summit, then contracting, the expanded portion having nodes on the margin (figs. 53–55.)
Group ε; with prominent carina with smooth expanded summit (fig. 57.)

These groups differ from the corresponding groups of Fenestella in the strong semi-circular projections.

I think there can be no valid objection to forming a new genus for these forms, for the semi-circular projections, frequently uniting and connecting adjacent carinæ, are certainly of as much generic importance as the connecting plates of Unitrypa or the connecting bars of Isotrypa.

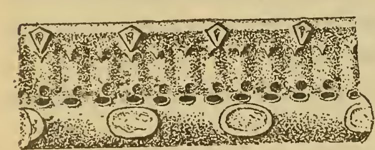
ISOTRYPA, Hall.

(Report of the State Geologist of New York, 1884, extract. Expl. pl. 2, figs. 13–16, 1885. See Pal. N. Y., vol. VI, pl. liv, figs. 10–21.)

This genus has some resemblance to Unitrypa, but in reality it is very different. In Unitrypa the carinæ are very prominent, and the scalæ or connecting processes are usually thin plates, nearly always extending one-half and frequently three-fourths the height of the carina, always oblique to the plane of the branch, generally sharply bent at about one-half their height, and, looked upon from above, always presenting an imbricated appearance, frequently, but by no means invariably, corresponding in number to the cell apertures. The carina is a continuous plane of equal strength.

In Isotrypa the connecting processes are round bars. The carina is not a continuous plane of equal strength, but is much thickened between the cell apertures upwards, so that it has, in a slight degree, the appearance of a series of pillars supporting a crest. When the carina is broken away the remains of the thickened portion are much more prominent than of the thin portion between, and appear on the branches as a median row of semi-circular nodes. On the carina, just above the posterior half of each cell aperture, is a circular indentation. They may possibly be pores opening into the carina, but none of the specimens that I have examined have been in a condition to prove this. On the carina, immediately below the expanded summit and between each two adjacent thickened portions of the carina, are two circular indentations, the space between them being elevated into a short, rather prominent triangular ridge, this riangular elevation being, of course, midway between the thickened portions of the carina (fig. 59.)

59



The expanded summit of the carina and the connecting processes have very much the appearance of the non-celluliferous face of a Fenestella. The characteristic feature of the non-celluliferous face is the large apertures or pores situated on or near the dissepiments.

TECTULIPORELLA, nov. gen.

(See Pal. N. Y., vol. VI, pl. liv, figs. 7, 8, 9; *Unitrypa? consimilis.*)

A form which has so far been of rare occurrence possesses characters which compel the formation of a new genus. This form has hitherto been placed with a query in the genus Unitrypa and is represented by the species *Unitrypa consimilis.*

As in the genus Unitrypa the carinæ are continuous plates, with expanded summits, connected by lateral processes; these processes are not oblique plates characteristic of Unitrypa, but strong bars resembling the dissepiments of the frond, the carinæ are very much expanded above, about equal in thickness to the branches of the frond, their summits and also the connecting bars are carinated, the whole structure resembling the non-celluliferous face of a Fenestella. The connecting bars are about equal in number to the dissepiments, but do not correspond to them in position.

The genus differs from Isotrypa in the fact that the carina is a continuous plate of equal strength. The summits of the carinæ and connecting bars are much stronger than in that genus, and much more closely resemble the non-celluliferous face of the frond. It also differs in the absence of the large pores on the non-celluliferous face of the frond. It can not be placed in the genus Tectulipora, which it most closely resembles, for in that the dissepiments are carinated in the same manner as the branches; of equal strength with the carinæ of the branches and coalescing with them, in this respect corresponding with the genus Loculipora. As it most closely resembles the genus Tectulipora I propose for this group the name Tectuliporella.

TECTULIPORA, Hall.

(See Annual Report of the State Geologist of New York, p. 305, pl. ix, figs. 7–11, 1887. Through some unaccountable error in the description of the plate the species figured is designated *Fenestella parallela.* It is needless to say it has no resemblance to that species.)

The next genus in natural order is Tectulipora. These forms differ from Tectuliporella in having the dissepiments as well as the branches carinated, the carinæ being greatly enlarged above. Though in looking down on this face of the fronds the general appearance of the two genera is the same, the manner of the formation of the connecting processes is radically different in this genus from Isotrypa and Tectuliporella. In those genera the connecting bars are lateral processes from adjacent carinæ, which, meeting midway between the two carinæ, coalesce and form continuous solid bars. In Tectuliporella, strictly speaking, there are no connecting bars or lateral processes. The features which resemble them are in reality the enlarged summits of the carinæ of the dissepiments, formed in the same manner as the enlarged summits of the carinæ of the branches and connecting with them. These features are shown in figure 60.

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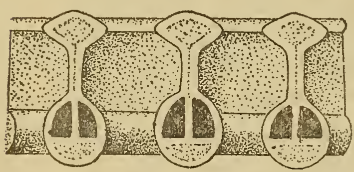

This genus is intermediate between Tectuliporella and Loculipora. It resembles Tectuliporella in having straight branches and all the apertures arranged in two parallel rows, but differs from it in the prominent carinæ on the dissepiments which are similar to those of the branches and coalesce with them.

It resembles Loculipora in having carinæ on the dissepiments, similar to and connecting with those of the branches, but differs from it in its straight branches and in the arrangement of the cell apertures in two parallel rows.

LOCULIPORA, Rominger.

(See Pal. N. Y., vol. VI, pl. liv, figs. 22–25, and Report of State Geologist for 1887, pl. x, figs. 1–13.)

The next genus in natural order is Loculipora. This name was given in manuscript by Dr. C. Rominger, and specimens received by him were so labeled. It was first published in the Palæontology of New York, vol. VI, p. 144, pl. liv, figs. 22–25. The branches are sinuous or zigzag, and on the celluliferous face both the branches and dissepiments are carinated. The carinæare very much enlarged above, and so exactly resemble the branches and dissepiments of the non-celluliferous face that it is impossible to distinguish one from the other. The cell apertures are not arranged in straight rows as in the preceding genus, but around the fenestrules, there being two cell apertures on each fenestrule.

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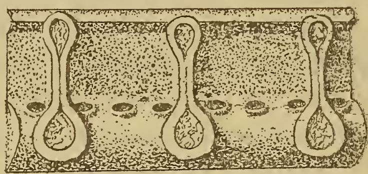

This genus differs from Tectulipora in having sinuous or zigzag branches, but the most important point of difference is the oval arrangement of the cell apertures around the fenestrules. Fig. 61 shows the carinæ of the dissepiments and branches.

FENESTRALIA, Prout.

(Trans. Acad. Sciences, St. Louis, 1858.)

"This Fenestella is characterized by a double row of cell apertures on each side of the mid rib, without a divisional keel between the two series of pores upon the sides. * * * The

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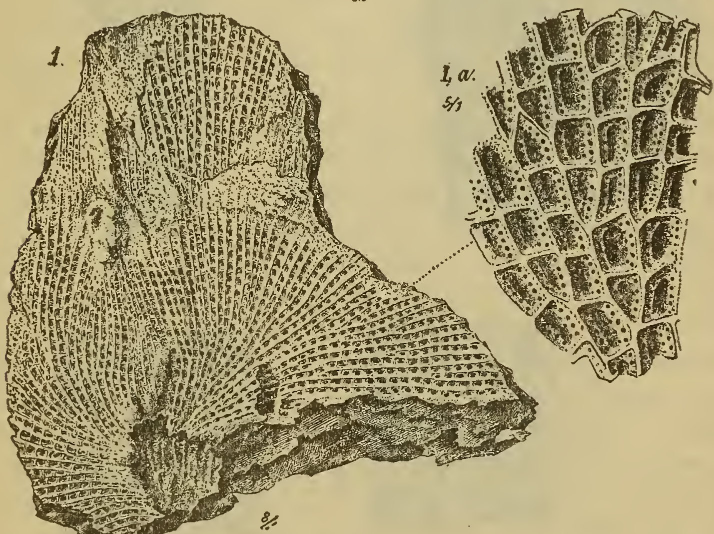

existence of two rows of pores on each side without a separating keel entitles it to be ranked as a sub-genera of Fenestella."

I have seen no specimen of this form, but give the original description and illustrations of Mr. Prout.

PHYLLOPORA, King.

(Monograph of the Permian Fossils of England, p. 40, pl. V, figs. 1–6.)

"Diagnosis.— A Fenestellidia consisting of infundibuliform folded, perforated fronds, or foliaceous expansions. Cellules on the whole of the outer or under surface of the fronds, and planted

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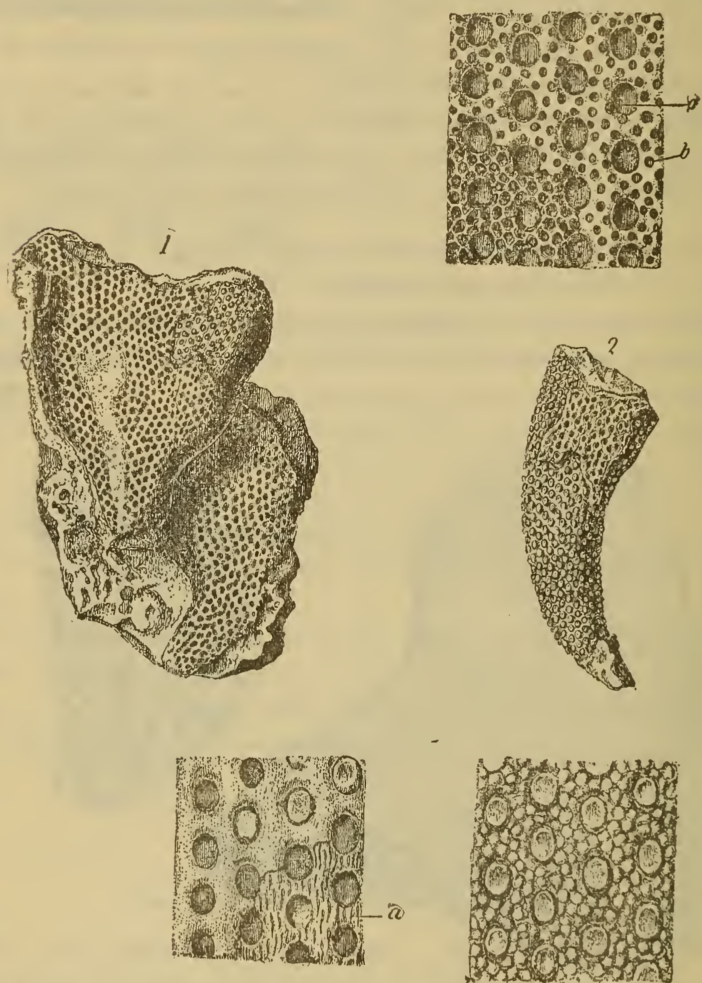

more or less approximating to a position at right angles to the plane of the capillary tubular basal plate. Cellular apertures with plain margins and parallel to the surface of the frond."

From a reference to the figures illustrating *Phyllopora Ehrenbergi*, the typical species, it will be seen that this description is somewhat misleading. The figures show that the general appearance of the genus is the same as that of an infundibuliform frond of Fenestella with wide dissepiments and differs from an uncarinated Fenestella in having apertures on the dissepiments as well as the branches.

In every case where a diagnosis differs from the illustrations I have unhesitatingly accepted the illustrations as authority in preference to the description, for it is almost impossible to describe the peculiarities of a genus so that its form is correctly reproduced in the mind of another; and with the multiplication of genera and species this becomes more and more difficult, while the different shades of meaning attached by different persons to the same words and phrases renders a description without illustrations practically useless. Also one may derive an entirely incorrect conclusion from what he observes, and the various parts of an organism may seem to him to serve a purpose entirely different from their real use; but having a correct drawing of an object before us is the same as if we had the object itself, and we can not be misled by inaccuracies in the description.

Holding these views I am pleased to find the following passage in British Fossil Brachiopoda by Davidson, who is without a rival in the clearness of his descriptions: "In 1852 in the second fasciculus of his important work, 'British Palæozoic Fossils,' Prof. McCoy described with great minuteness 118 species or varieties of British Palæozoic Brachiopoda, but of these he figures only twenty-five. It is much to be regretted that a larger number of the fossils had not been illustrated, for a good figure is often more valuable than the most elaborate description, and especially so when forms vary so slightly from one another that at times it is hardly possible to adequately express with words small differences which the figure at once conveys to the eye of the experienced observer." Beale, in "How to Work With the Microscope," says: We may reasonably hope that those who follow us will look at our drawings, if we are careful to make honest copies of nature, but we can hardly expect that much of which is now written will be read some years hence, when the whole aspect of the department of science we love to develop will be completely changed.

SYNOCLADIA, King.

(Monograph of the Permian Fossils of England, p. 38, pl. iv, figs. 3, 5, 1849.)

"Diagnosis.—A foliaceous or frondiferous infundibuliform Fenestellidia; fronds consisting of numerous connected stems or

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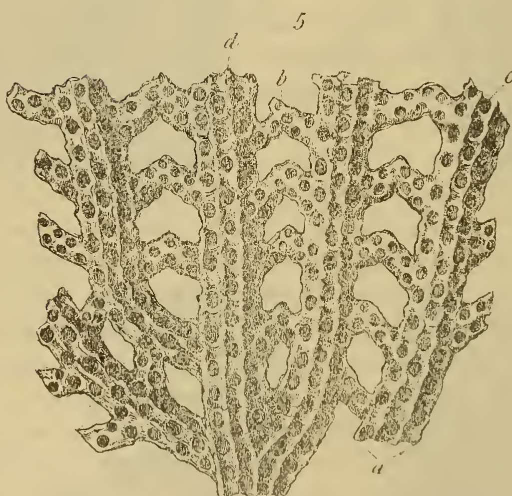

ribs; stems bifurcating, radiating from a small root, running parallel to and a short distance from each other on one plane and giving off bilaterally numerous short, simple branches, of which opposite pairs conjoin midway between the stems accurately and at an ascending angle."

All dissepiments are formed in the same manner as the bilateral "simple branches of Synocladia," namely, by lateral projections, of which opposite pairs conjoin midway between the branches.

These dissepiments in the interior are always more or less celluliferous, frequently entirely so.

Frequently in Polypora the dissepiments have several cell apertures on the surface, as shown in a previous portion of this paper, and much more emphatically by Mr. Prout in Transactions of the St. Louis Academy of Science and by Waagen (Paleontologia Indica; Salt-Range Fossils, Vol. I, pls. xc, xci), and uniformly the dissepiments of Phyllopora have cell apertures on the surface.

The lateral branches of Synocladia are formed in precisely the same manner as the dissepiments of the other forms of the family Fenestellidæ, and I can see no valid reason for considering them as radically different, and on that account to place this form in another family as has been done by some writers; in fact, Dr. King himself, although in his generic description speaking of them as bilateral branches, in his description of *S. virgulacea*, the type species, speaks of them as branches or connecting processes.

Synocladia differs from Polypora, which it most closely resembles, in the angular or arcuate character of the dissepiments, and in their pronounced celluliferous character with cell apertures on the surface. It differs from Septopora in precisely the same manner that Polypora differs from Fenestella, in the fact that there are more than two ranges of cell apertures on the branches.

SEPTOPORA, Prout.

(Trans. Acad. St. Louis, 1858, p. 448, pl. iv, figs. 1, 2b and 2c.)

Generic description.—"Bryozoum a fan-like expansion, radiating from a center, branching and occasionally anastomosing, having two lines of pores, one on each side of a tuberculated conduit. Dissepiments forming arches more or less angular, dividing the bryozoum into quadrangular, round, semi-lunar or rhomboidal fenestrules; each dissepiment supporting from one to four irregular lines of cell pores ; reverse smooth when worn ; more or less tubercled when perfect.

I have established a genus on the character of the dissepiments, which are more celluliferous than the longitudinal rays.

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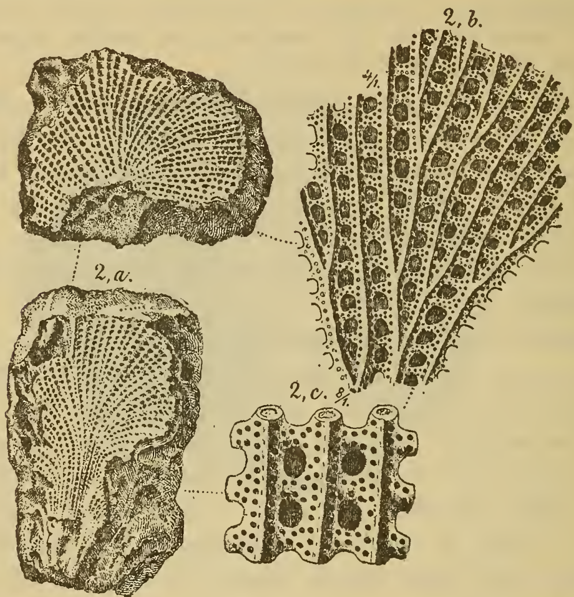

Though in its generic features it resembles Fenestella, it differs in a marked degree by its celluliferous dissepiments."

This genus differs from Synocladia in having only two rows of cell apertures separated by a carina.

HELICOPORA, Claypole.

In February, 1883, in the Quarterly Journal of the Geological Society, p. 32, Prof. E. W. Claypole proposed the new genus Helicopora, which he described as follows:

" Polyzoary expanded, fenestrate and spiral, formed of slender bifurcating rays, poriferous on one face, connected by non-poriferous bars, forming an open network ; cells arranged in two rows along the rays, one row on each side of a median keel ; axis none, or consisting only of the thickened inner border of the polyzoary, not straight but forming a spiral, rounded, non-poriferous or slightly poriferous inner margin."

In examining specimens from the Falls of the Ohio, I have occasionally met with individuals of the genus Fenestella having one margin much thickened and with a tendency to a spiral mode of growth, but they were only aberrant forms of well-known species.

If several specimens of this species have been found and the form is persistent, it will be interesting as the first step in the gradual change from the typical Fenestella to Archimedes, *Archimedes laxus* being another step toward the typical form of Archimedes.

ARCHIMEDIOPORA, D'ORBIGNY.

The structural character or the remains of fenestrules on the axis, as seen in Dr. Owen's figure, have been mistaken by d'Orbigny for the animal cells, and upon this character he proposed the new genus Archimediopora, having the cells arranged upon the salient angles of the spiral band.

LYROPORA, HALL.

The genus Lyropora was first described by Prof. James Hall (Proc. Amer. Acad. Sciences, 1857, p. 179; no illustrations.) "Bryozoum consisting of foliated reticulated expansions, margined on either side by strong stony supports, which diverge from the base, curving outward and upward. The foliate expansion is spread out between these diverging arms, which are themselves formed by the coalescing and thickening of the branches. The growth of these strong supports is sometimes direct or in a line parallel with the point of attachment; and in other cases there is at first a receding of the whole from that point, an extreme thickening of the supports on one side and a gradual narrowing to the opposite points where the branches originate.

"These bifurcating processes with the point of attachment resemble the lower jaw of the common frog, and are known along the Mississippi valley as the 'frog-mouth coral.'"

Fenestella ladus, the typical species, has the branches round and with four or five rows of cell apertures.

LYROPORINA, nov. gen.

The typical species of Lyropora has three or more ranges of cell apertures; other species have only two ranges; for these forms I propose the name Lyroporina. They have the same relation to Lyropora as has the genus Fenestella to Polypora.

LYROPORELLA, nov. gen.

For the same reasons which induced me to propose the genus Polyporella for the forms intermediate between Fenestella and Polypora, I propose the genus or sub-genus Lyroporella for those forms intermediate between Lyropora and Lyroporina, which have two ranges of cell apertures on the narrower portion of the branches and three or more on the wider portions.

The same arguments which were used in regard to the genus Polyporella apply with equal force to Lyroporella.

Lyropora, Lyroporella and Lyroporina differ from Polypora, Polyporella and Fenestella only in the manner of growth.

It is necessary that the thickened margins of the former genera should be present to distinguish fragments of them from fragments of the latter genera.

Resume.

In this paper the following genera of Fenestellidæ are mentioned:

Fenestella.— Forms having two ranges of cell apertures under the following groups:

Group α. Fenestella (humilis), with low, smooth carinæ.

Group β. Fenestella (nodata), with nodes or low nodose carinæ.

Group γ. Fenestella (laminata), with very prominent equal, thin carinæ.

Group δ. Fenestella (mediadilata), with carinæ expanding midway of their height, then contracting, the expanded portion having nodes on the margin.

Group ϵ. Fenestella (summidilata), with prominent carinæ, summits expanded, margins smooth.

Group ζ. Fenestella (prætexta), with prominent carinæ, expanded at the summit, margins nodose.

Flabelliporina.— Branches and dissepiments similar to Fenestella, but having a flabellate mode of growth.

Fenestralia.— Forms resembling Fenestella, but having two ranges of cell apertures on each side of a median keel.

Polypora.— Similar to Fenestella, but having three or more ranges of cell apertures not separated by a carina.

Flabelliporella.— Forms which have the branches and dissepiments similar to Polypora, but having a flabellate mode of growth.

Polyporella.— Forms intermediate between Fenestella and Polypora in the number of ranges of cell apertures.

Fenestrapora.— Forms having pores on the summit of the carinæ and conspicuous pores on the non-celluliferous face of the frond.

Reteporella.— Forms having branches connected by anastomosis, and with three or more ranges of apertures on the celluliferous face.

Reteporina.— Forms similar to Reteporella, but having only two ranges of cell apertures.

Ptiloporina.— Infundibuliform fronds having a general resemblance to Fenestella, but with some of the branches larger than the others, the ordinary branches proceeding laterally from one or both sides of the larger branches, three or more ranges of apertures on a branch.

Ptiloporella.— Infundibuliform fronds resembling the preceding, but having only two ranges of cell apertures.

Pinnaporina.— Branches and dissepiments similar to Ptiloporina, but having a flabellate mode of growth.

Pinnaporella.— Forms having a general resemblance to the preceding, but having three or more ranges of cell apertures.

Semicoscinium.— Unitrypa.

Cycloporina.— Forms having prominent semi circular projections from the carinæ over the dissepiments, the opposite ones frequently uniting. The forms of this genus have been placed in several groups, from the character of the carinæ. The groups have the same value as the corresponding groups in Fenestella.

Group *α*.

Group *β*.

Group *γ*.

Group *δ*.

Group *ε*.

Group *ζ*.

Unitrypa.— Forms with prominent carinæ which are connected by thin oblique plates.

Hemitrypa.— Forms where the carinæ are apparently connected by lateral processes, which are not opposite, but coalesce midway between the carinæ and form a ridge or pseudo-carina.

Isotrypa.— Forms with prominent carinæ connected by distant round bars, and with prominent pores on, or near the dissepiments of the non-celluliferous face.

Tectuliporella.— Forms of which the carinæ and connecting processes resemble in a marked degree the non-celluliferous face of the frond. The connecting bars do not correspond in number to the dissepiments. Reverse face non-poriferous.

Tectulipora.— Forms having both branches and dissepiments carinated, the carinæ much expanded above, coalescing and having the appearance of the non-celluliferous face of a frond, apertures in continuous rows.

Loculipora.— Forms having the same manner of growth as the preceding, but the cell apertures are arranged in an oval around the fenestrules, there being two apertures on each dissepiment.

Phyllopora.— Forms resembling Fenestella but having apertures on the dissepiments.

Synocladia.— Forms in which the lateral processes from each branch are oblique, forming an angular dissepiment, sometimes irregular; three or more ranges of cell apertures, dissepiments cellular.

Septopora.— This form differs from the preceding in having only two ranges of cell apertures, which are separated by a carina.

Helicopora.— A semi-spiral fenestelloid form.

Archimedes.— A fenestelloid form having a spiral mode of growth; two ranges of cell apertures.

Archimediopora.— Similar to the preceding, but having three or more ranges of cell apertures.

Lyropora.— A flat, expanding form, with thickened margins. Three or more ranges of cell apertures.

Lyroporina.— Similar to the preceding but having only two ranges of cell apertures.

Lyroporella.— Forms intermediate between Lyropora and Lyroporina.

Of these thirty genera, ten genera and six groups have been for the first time proposed in this paper, as follows:

Groups of Fenestella.

α (humilis).
β (nodata).
γ (laminata).
δ (mediadilata).
ε (summidilata).
ς (prætexta).

Flabelliporina.
Polyporella.
Flabelliporella.
Reteporella.
Pinnaporina.
Pinnaporella.

Groups of Cycloporina.

α, β, γ, δ, ε, ζ — Corresponding to the same groups under Fenestella.

Tectuliporella.
Lyroporina.
Lyroporella.

GLOSSARY AND EXPLANATIONS

OF SPECIFIC NAMES OF

BRYOZOA AND CORALS

DESCRIBED IN

VOLUME VI, PALÆONTOLOGY OF NEW YORK

AND OTHER REPORTS.

BY GEORGE B. SIMPSON.

GLOSSARY AND EXPLANATIONS

OF

Specific Names of Bryozoa and Corals Described in Volume VI, Palæontology of New York and Other Reports.

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ABRUPTA, Monotrypella — from the abrupt turning outward of the cell tubes near the surface.

ACAULIS, Polypora — without a stem, without a pedicel, spreading directly from the radicle.

ACCLIVIS, Unitrypa — arising, ascending; from the form and direction of the scalæ.

ACULEATA, Polypora — prickly; from the numerous prickles or spine-like nodes on both faces of the frond.

ACULEOLATA, Cœlocaulis — from the small conical nodes or spinules.

ADNATA, Polypora — growing together from the beginning; from the close connection or anastomosing of the branches.

ADORNATA, Fenestella — ornamented; from the ornamentation of the branches.

ÆQUALIS, Fenestella — similar or equal to; the branches and dissepiments are of the same appearance and size.

ALTERNATA, Lichenalia — from the usual arrangement of the cell apertures.

ALTERNATA, Stictopora — the cell apertures of adjacent rows are alternating.

ALTERNATUM, Acanthoclema — the nodes and cell apertures are disposed in parallel rows and alternate.

ALTICARINA, Fenestella — from the high carina.

ALVEATA, Odontotrypa — channeled; from the concave or channeled surface between the cell apertures.

AMBIAPERTURA, Fenestella — from the apertures on both faces of the frond.

AMBISTRIATA, Fenestella — from the striations on both faces of the frond.

AMPLECTENS, Paleschara — enclasping; from the usual manner of growth, i. e., enclasping crinoid stems.

ANGULARIS, Stictopora — from the angles of the marginal portion of the frond.

ANGULATA, Fenestella — having angles; from the angular branches.

ANGUSTATA, Fenestella — straight, narrow, confined; from the comparatively small, compact frond with straight and rigid branches.

ANNULATA, Trematella — annulated; from the elevated annulations or ridges about the branches.

APERTA, Fenestella — wide open; from the appearance of the frond.

ARBOREA, Trematella — tree like; from the form of the frond.

ARBUSCELLUS, Monotrypella — resembling a little tree or shrub; from the form of the frond.

ARTA, Polypora — straight, narrow; from the appearance of the frond.

ASSITA, Fenestella — situated or placed near; from the fact that on the celluliferous face the branches are nearly in contact.

BIFRONDA, Hemitrypa — two-fronded; the species has the appearance of being composed of two fronds, one enveloping the other.

BIFURCATA, Stictopora — bifurcated; from the frequency of the bifurcations.

BI-IMBRICATA, Fenestella — the dissepiments of the non-celluliferous face and the carinæ of the celluliferous face are imbricating.

BIPERFORATA, Fenestropora.— Each face of the frond is perforated, one with the cell apertures, the reverse with the triangular apertures, the use of which is at present unknown.

BISERIALIS Hemitrypa — from the two ranges of fenestrule-like openings between adjacent carinæ.

BISERRULATA, Fenestella — from the row of serrulations on each side of the high carinæ.

BISPINULATA, Orthopora — from the two spinules between adjacent cell apertures.

BISTIGMATA, Semipora — from the two punctures or pits between adjacent cell apertures.

BISTRIATA, Lichenalia — from the two parallel plications or elevations along the interior of the cell walls.

BREVIJUNCTURA, Fenestella — junctura, that which joins, dissepiments; from the short dissepiments.

BREVISULCATA, Polypora — from the short sulci or channels in the surface of the branch below the bifurcations.

BULLATA, Lichenalia — inflated, swollen like a bubble; from the numerous convex interapertural elevations.

CAMERATA, Diamesopora — having an arched covering; from the lower portion of the peristomes partially covering the cell apertures.

CANALICULATA, Orthopora — having small channels or grooves; from the channels between the cell apertures.

CARINATA, Coscinotrypa — from the angular elevations of the surface of the fronds.

CARINATA, Orthopora — from the ridges between the cell apertures.

CARINELLA, Polypora — from the slight elevations or carinæ between the ranges of cell apertures.

CELLULOSA, Callopora — from the numerous cell apertures and large interapertural mesopores.

CELSICARINA, Fenestella — from the high carina.

CELSIPORA, Polypora — from the prominent peristomes and therefore conspicuous cell apertures.

CINCTUTA, Lyropora — girdled, belted; from the thickened margins of the frond.

CIRCINCTA, Lichenalia — surrounded, hemmed in; from the elevations surrounding the cell apertures.

CIRCUMSTATA, Loculipora — placed around; from the cell apertures entirely surrounding the fenestrules.

CLATHRATA, Fenestella — from the reticulated appearance of the frond.

CLATHRIFORMIS, Fenestella — form of a grating, lattice-like; from the appearance of the frond.

CLAUSTRATA, Fenestella — barred; the dissepiments have the appearance of bars.

CLAVIFORMIS, Stictoporina — club-shaped; from the form of the branches.

CLIVULATA, Pileotrypa — having small elevations; from the monticulæ of the surface.

COLLICULATA, Lichenalia — having small hills; from the convex elevations of the surface.

COLUMELLATA, Hemitrypa — when the carinæ are broken away the branches appear to have numerous minute columns along the middle of the branch.

COMPACTA, Polypora — from the compact appearance of the frond.

COMPLEXATA, Selenopora — encircled; from the thin elevations surrounding the cell apertures.

COMPRESSA, Polypora — from the compressed branches.

CONCENTRICA, Paleschara — from the concentric arrangement of the cell apertures.

CONFERTIPORA, Fenestella — from the crowded cell apertures.

CONFUSA, Lichenalia — from the crowded and confused appearance of the cell apertures.

CONICA, Ptiloporina — the broader portion of the frond is usually affixed to the rock and the frond has the appearance of a cone.

CONICUS, Favosites — from the usual form of the species.

CONJUNCTIVA, Isotrypa — that which connects; the species occupies a position midway between Unitrypa and Loculipora, uniting the two genera.

CONSIMILIS, Tectiporella — alike; the branches and dissepiments of the non-celluliferous face and the summits of the carinæ and connecting bars of the celluliferous face have the same appearance.

CONSTRICTA, Diamesopora — the great development of the lower portion of the peristomes constricts the cell apertures.

CONTACTA, Fenestella — from the fact that the branches of the celluliferous face are nearly or quite in contact.

CONTRASTA, Fenestella — from the contrast in size between the branches and dissepiments.

CONULATA, Lichenalia — having small cones; from the cones or conical elevations of the surface.

CORNUTA, Fistulipora — having horns; from the two denticulations or horn-like projections from the peristomes.

CORONIS, Fenestella — from the wide carinæ or crowns of the celluliferous face of the branches.

CORTICOSA, Trematella — having a thick bark; from the appearance of the surface of the branches.

COSCINIFORMIS, Ptilodictya — resembling a Coscinium.

CRASSA, Fistulipora — thick; from the thick frond.

CRATERIFORMIS, Fenestella — from the form of the frond.

CREBESCENS, Polypora — to grow frequent; from the rapid increase in the number of the branches.

CREBRIPORA, Fenestella — numerous pores; from the numerous cell apertures.

CRENULATA, Stictopora — from the crenulated margins of the frond.

CRIBROSA, Hemitrypa — from the numerous circular fenestrules of the hemitrypic face, giving to that face of the frond a sieve-like appearance.

CRISTATA, Phractopora — crested; from the sharp angular elevations or crests of the frond.

CULTELLATA, Lichenalia — edged or sharp, like a knife; from the sharp elevations extending from the centers of the monticulæ.

CULTRATA, Fenestella — from the knife-like carinæ of the celluliferous face.

CURVATA, Bactropora — from the curved frond.

CURVIJUNCTURA, Fenestella — from the curved dissepiments.

DECIPIENS, Fistulipora — deceiving; when the frond is perfectly preserved, it would easily be mistaken for some form of Paleschara, but when slightly worn or macerated the characteristics of the genus Fistulipora are plainly seen.

DENSA, Monotrypella from the crowded cell apertures.

DENTICULATA, Fenestella — from the numerous radial denticles.

DENTICULATA, Pileotrypa — from the two prominent projections from the peristome.

DEPRESSA, Fenestella — from the decided depression of the dissepiments on both faces of the frond.

DICHOTOMA, Diamesopora — from the frequent bifurcations.

DIFFERENS, Fenestella — from the fact that the frond presents a varying appearance according to the different degrees of weathering.

DIGITATA, Fistulipora — from the digitate form of the frond.

DILATATA, Prismopora — from the unusual breadth of the frond.

DISPANDA, Fenestella--stretched out, expanded; from the straggling appearance of the frond.

DISPARILIS, Ptiloporina -- dissimilar, unlike; from the difference in the manner of growth and appearance of the main and lateral branches.

DISPERSA, Diamesopora — from the scattered cell apertures.

DISSITAS, Fenestella — distant, remote; from the distant nodes.

DISTANS, Lichenalia — the cell apertures are not closely disposed.

DISTENSA, Lichenalia -- stretched out, extended; from the wide fronds.

DIVARICATA, Thamnopora — stretched wide; the branches are at right angles.

DIVERGENS, Acanthoclema-- from the wide divergence of the branches.

DIVERGENS, Stictopora — from the wide divergence of the frond at the bifurcations.

ELEGANS, Pollypora — from the elegant appearance of the frond.

ELEGANTISSIMA, Unitrypa — from the unusually beautiful appearance of the frond.

ELEGANTULA, Coscinella — from the very handsome appearance of the surface and interior of the frond.

ELONGATA, Orthopora — from the elongate cell apertures.

EMACIATA, Fenestella — from the poor, emaciated appearance of the frond.

ERECTIPORA, Fenestella — from the fact that the cells open directly outward, or as the frond lies on the rock, directly upward, and the peristomes are prominent.

EXORNATA, Fenestella — ornamented; from the sculpturing of the non-celluliferous face of the frond.

FASCICULATA, Clonopora — like a small bundle; from the appearance of the cell tubes, resembling a bundle of sticks.

FASTIGATA, Unitrypa — sloping; from the sloping of the scalæ.

FAVOSA, Hemitrypa — like a honeycomb, full of cells; from the fact that the hemitrypic face resembles a miniature honeycomb.

FICTITIA, Unitrypa — feigned, counterfeit; the under side of the carinæ and scalæ, in a remarkable degree, resemble, or counterfeit the celluliferous face of a Fenestella.

FILIFORMIS, Fenestella — thread-like; from the slender, thread-like branches.

FISTULATA, Polypora — hollowed out; should have been fistulosa, full of holes, like a sponge; from the numerous cell apertures.

FLABELLATA, Fenestella — fan-shaped; from the form of the frond.

FLEXA, Fenestella — bowed, curved; from the bowing or curving of the dissepiments.

FOLIACEA, Ceramopora — leaf-like; from the form of the frond.

FREQUENS, Fenestella — from the frequency of the dissepiments. They are very closely disposed, resembling the scalæ of an Unitrypa.

FRUTICELLA, Thamniscus — a little shrub; from the form of a frond.

FRUTICOSA, Stictopora — bushy, full of twigs; from the numerous bifurcations of the frond.

FUSCA, Fenestella — brown; from the color of the type specimen.

GALLICAUDA, Fenestella — like a cocktail; from the form of the frond.

GENICULATA, Callopora — having a knee or angle; from the resemblance of the cell tubes to a bent leg.

GEOMETRICA, Lichenalia — from the appearance of the maculæ of the frond.

GRANATULA, Stictopora — from the granules on the elevations between the cell apertures.

GRANIFERA, Fenestella — from the numerous granules ornamenting the non-celluliferous face of the branches.

GRANILINEA, Polypora — from the granulose striæ or elevations of the non-celluliferous face of the frond.

GRANISTRIATA, Bactropora — from the granulose striæ between the ranges of cell apertures.

GRANULOSA, Rhinidictya — from the numerous granules on the surface.

HEMICYCLA, Cycloporina — shaped like a semi-circle, hence, anything of a semi-circular form; from the semi-circular projection and the carina over each dissepiment.

HEMISPHÆRICA, Fistulipora — from the hemispheric form of the frond.

HEXAGONA, Orthopora — from the hexagonal form of the cell apertures.

HEXAGONALIS, Polypora — from the hexagonal form of the fenestrules.

IMBRICATA, Ceramopora — from the imbricating cell tubes.

IMMERSA, Arthropora — the cell apertures are immersed, being surrounded by polygonal elevations.

INCISURATA, Stictopora — having an incision, notched; from the incised or notched margin of the frond.

INCLUSA, Favicella — inclosed; the cell apertures are inclosed by sharp polygonal elevations.

INCRASSATA, Stictopora — thickened; from the thick frond.

INCRUSTANS, Paleschara — incrusting; from the manner of growth of the frond, incrusting other objects.

INCURVA, Clonopora — curved or crooked; from the curved cell tubes.

INEQUALIS, Ptiloporella — unequal; from the unequal size of the branches.

INFREQUENS, Ptilopora — from the infrequent lateral branches.

INOPINATA, Polypora — surprising; the non-celluliferous face bears an exact resemblance to F. latitruncata and one is, therefore, surprised to find from the celluliferous face that the specimen is a Polypora.

INTERASPERA, Fistulipora — rough between; the granules from a roughened surface between the cell apertures.

INTERCELLA, Paleschara — from the numerous small cells between the large ones.

INTERCELLATA, Fistulipora—from the numerous mesopores between the cell apertures.

INTERNODATA, Callotrypa — from the nodes between the cell apertures forming the most prominent feature of the surface.

INTERPLANA, Orthopora — from the flat surface between the cell apertures.

INVERTIS, Stictopora — inverted; from the inverted or V-shaped transverse rows of apertures.

INVOLVENS, Paleschara— to wrap up or cover; from the manner of growth of the frond incrusting or covering up other objects.

IRPIFORMIS, Fenestella — like a harrow; the prominent nodes somewhat resemble the teeth of a harrow.

IRREGULARIS, Cœlocaulis — from the irregular arrangement of the cell apertures.

JUNCEUS, Fenestella — resembling rushes; from the appearance of the frond.

LABIATA, Fenestella — having lips; from the appearance of the peristomes indenting the fenestrules.

LACUNATA, Fenestella — channeled, having grooves; from the appearance of the non-celluliferous face of the fronds.

LÆVINODATA, Polypora — having little nodes; from the small nodes of the non-celluliferous face.

LEVISTRIATA, Polypora — from the thin, slight elevations between the ranges of cell apertures.

LAMELLATA, Fistulipora — from the lamellate frond.

LARGISSIMA, Polypora— from the large size of the branches and fenestrules.

LATA, Prismopora — from the wide frond.

LATICARINA, Fenestella — from the wide summits of the carinæ.

LATIJUNCTURA, Fenestella — from the wide dissepiments.

LATITRUNCATA, Polypora — from the wide branches.

LENTICULARIS, Fenestella — from the lenticular form of the fenestrules.

LINEARIS, Stictopora — from the very narrow frond.

LINEATA, Orthopora — from the small size appearing as a line.

LINEATA, Phractopora — from the slight angular elevations or lines on the surface.

LIRATA, Ptilodictya — like the ridges between furrows, from the prominent, longitudinal parallel furrows.

LOBATA, Stictopora — from the lobes on the margin of the frond.

LOCULATA, Tectulipora — having compartments or divisions; referring to the space inclosed by the carinæ of the branches and dissepiments.

LONGISPINA, Lichenotrypa — from the prominent spines of the surface.

LUNULATA, Fenestella — from the crescent-like elevations on the dissepiments.

MACROPORA, Callotrypa — from the large cell apertures.

MACULOSA, Lichenalia — from the numerous maculæ of the surface.

MAGNIPORATA, Fenestrapora — from the large pores of the non-celluliferous face.

MARCIDA, Fenestella — shrunken; from the appearance of the branches.

MEDIA, Fenestella — from the position of the cell apertures on the side of the branches midway between the two faces.

MEDIAPORA, Cœlocaulis — from the large mesopores.

MICROPORA, Lichenalia — from the minute cell apertures.

MONTICULATUS, Chætetes — from the prominent monticulæ.

MULTIACULEATA, Fenestella — from the numerous conical nodes or spines of the celluliferous face.

MULTILOCULARIS, Fenestella — many celled ; from the numerous cells.

MULTIPLEX, Polypora — in the sense of many; numerous; from the numerous cell apertures.

MULTIRAMUS, Thamniscus — from the numerous branches.

MULTISERIATA, Callopora — from the numerous longitudinal series of cell apertures.

MUTABILIS, Polypora — changeable; different portions of the frond vary in appearance.

NANA, Unitrypa — a dwarf; from the small size of the frond.

NEXA, Orthopora — tied in a knot; from the appearance of the nodes, and the elevations surrounding the cell apertures.

NEXILIS, Fenestella — knotted; the frond resembles knotted cords or a net.

NODATA, Reptaria — from the numerous nodes on the surface of the frond.

NODICARINA, Fenestella — from the nodose carina.

NODIJUNCTURA, Fenestella — from the nodes on the dissepiments.

NODOSA, Orthopora — from the numerous nodes of the surface.

OBLIQUA, Fenestella — from the fact that the outer range of cell apertures are oblique to the axis of the branch.

OBLIQUAPORA, Fenestella — from the oblique cell apertures.

OBSOLETA, Stictopora — obsolete; from the fact that the greater portion of the specimens at first observed were much worn or macerated, and the cell apertures were nearly or quite obsolete.

OCCULTA, Fenestella — hidden; from the fact that the cell apertures are concealed or hidden by the prominent carina.

OCULIFERA, Callotrypa — bearing lips; from the prominent peristomes.

OMNIPORATA, Fenestella — all pores; from the fact that in addition to the pores or cell apertures of the celluliferous face, there are numerous pores on the non-celluliferous face.

OPERCULATA, Fenestella — from the conspicuous opercula of the cell apertures.

OPPLETA, Fenestella — filled completely, i. e., the surface by the cell apertures.

ORBIPORA, Orthopora — from the circular form of the cell apertures.

ORNATA, Orthopora — from the ornamentation of the surface.

OVATA, Stictopora — from the ovate cell apertures.

OVATIPORA, Stictopora — from the ovate cell apertures.

PALANS, Fenestella — straggling; from the manner of growth of the frond.

PALIFORMIS, Glossotrypa — spade-shaped; from the form of the cell apertures.

PALMIPES, Stictopora — web-footed; from the appearance of the frond.

PAPILLOSA, Stictopora — from the papillose appearance of the cell apertures.

PARALLELA, Fenestella — the branches of the fronds are essentially parallel.

PARALLELA, Orthopora — the cell apertures are disposed in parallel rows both transversely and longitudinally.

PARALLELA, Ptilodictya — from the parallel ridges between the ranges of cell apertures.

PARASITICA, Fistulipora — from the very thin frond growing on other objects.

PARVICELLA, Ceramopora — from the small cells.

PARVIRETIS, Reteporina — from the resemblance of the frond to a small net.

PAUCIPORA, Callotrypa — from the few cell apertures.

PAUCIRAMA, Prismopora — from the distant branches.

PAUCIRAMUS, Thamniscus — from the scarcity of branches.

PECULIARIS, Fenestella — from the peculiar appearance of the frond.

PERARCTA, Stictopora — very narrow; from the shape of the frond.

PERCRASSA, Polypora — very thick; from the unusual thickness of the frond.

PERELEGANS, Callopora — from the beautiful appearance of the species.

PERFORATA, Loculipora — the fenestrules of the carinæ and non-celluliferous face are opposite, so that the frond has a perforated appearance.

PERMARGINATA, Fenestella — from the strong elevations around the fenestrules on the non-celluliferous face.

PERPLEXA, Fenestella — perplexing; at first glance it is difficult to decide whether this species should be placed in the genus Fenestella or Unitrypa.

PERSPINULA, Fenestella — from the strong conical nodes or spines of the surface.

PERTENUIS, Fenestella — from the very slender branches of the frond.

PERTENUIS, Paleschara — from the very thin frond.

PERTEREBRATA, Fenestella — bored through; from the conspicuous cell apertures.

PERUNDATA, Polypora — very undulating, from the undulations of the frond.

PERUNDULATA, Reteporina—from the undulatory appearances of the branches.

PINNATA, Ptiloporina — feather-shaped; from the appearance of the frond.

POROSA, Polypora— full of pores; from the numerous cell apertures.

PORRECTA, Fenestella — stretched out, extended; the cell apertures extend upon the dissepiments.

PRÆCURSOR, Fenestella — a forerunner; this species is almost a Unitrypa, a forerunner of that species.

PRÆGRACILIS, Fenestella—very slender or narrow, i. e., the branches.

PROCERITAS, Fenestella — should have been *procera*, long; referring to the elongate dissepiments.

PROLIFERA, Acrogenia —bearing offspring; referring to the peculiar manner of growth, each branch having two others proceeding from its summit.

PROMINENS, Fenestella—prominent; from the prominent peristomes.

PROPRIA, Fenestella — peculiar, not common; the appearance of the frond is strikingly different from that of any other species.

PULVERATA, Fenestella — covered with dust; the numerous granules of the non-celluliferous face gives a sanded or dusty appearance to the branch.

PUMICOSA, Fenestella — full of holes, like a pumice-stone; from the cell apertures and numerous pores of the non-celluliferous face.

PYRIFORMIS, Pileotrypa — pear-shaped; the elongate swelling peristomes are usually pear-shaped.

QUADRANGULARIS, Polypora — quadrangular; on the non-celluliferous face the carina of the dissepiments and the connecting branches give to the fenestrules the appearance of being surrounded by a quadrangular elevation.

QUADRULA, Fenestella — a little square; from the square fenestrules.

RADIATA, Paleschara — radiating; the cell apertures radiate from the maculæ.

RAMOSA, Lichenalia — ramose; from the form of the frond.

RECTA, Stictopora — straight; from the form of the species.

RECTALINEA, Stictopora — straight lines; from the disposition of the cell apertures in straight parallel lines.

RECUBANS, Stictopora — reclining; from the almost horizontal position of the cell tubes.

REGULARIS, Orthopora — regular; from the regular disposition of the cell apertures in parallel longitudinal rows.

RETICULATA, Orthopora — reticulate, netted; from the reticulate appearance of the surface.

RETIFORMIS, Ptilodictya — like a net; from the appearance of the surface.

RECTIFORMIS, Reteporina — from the appearance of the frond.

RHOMBIFERA, Reteporina — from the rhomboidal form of the fenestrules.

RHOMBOIDEA, Stictopora — from the rhomboidal form of the cell apertures.

RIGIDA, Polypora — rigid; from the stiff, rigid appearance of the frond.

RIGIDA, Stictopora — from the stiff appearance of the frond.

ROBUSTA, Polypora — robust, strong; from the large, strong branches and dissepiments.

ROBUSTA, Vermipora — from the large size of the cell tubes.

SCALARIFORMIS, Scalaripora — like a ladder; the transverse elevations or scalæ resemble the steps of a ladder.

SCALARIS, Unitrypa — of or belonging to a ladder or stair; the scalæ resemble stairs.

SCIDACEA, Ceramella — like a piece of paper; from the very thin frond.

SCITULA, Stictopora — pretty; from the appearance of the frond.

SCUTULATA, Orthopora — diamond shaped, formed with lozenges; from the shape of the cell apertures.

SCUTULATUM, Acanthoclema — from the rhomboidal outline of the cell apertures.

SEGREGATA, Fistulipora — separated; from the scattered cell apertures.

SEMIREDUCTA, Clonopora — half drawn back, retracted; from the bent form of the cell tubes.

SEMIROTUNDA, Cycloporina — half round, semi-circular; from the form of the projections from the carina.

SEMISTRIATA, Stictopora — half striated; the branches are only partially striated.

SIMPLEX, Nemataxis — simple; from the character of the frond.

SINGULARITAS, Fenestella — the being one or alone; referring to the fact that there is one node and only one below each bifurcation.

SINISTRALIS, Ptiloporina — from the left; from the fact that the smaller or secondary branches all proceed from the left side of the larger ones.

SINUOSA, Fenestella — sinuous; from the sinuous branches.

SINUOSA, Stictopora — sinuous; from the sinuous longitudinal striations between the cell apertures.

SOCIALIS, Botryllopora — from the fact that the species is always found in colonies of many individuals.

SPARSIPORA, Prismopora — few pores; from the scattered cell apertures.

SPHÆRICUS, Favosites — spherical; from the form of the species.

SPHEROIDEA, Fistulipora — round, spherical; from the form of the species.

SPINULOSA, Monotrypella — full of little spines; from the numerous spinules at the angles of the cell apertures.

SPISSA, Fenestella — thick, crowded; from the numerous branches in a small space.

STELLATA, Fenestella — studded with stars; the summits of the numerous nodes are usually star-shaped.

STIPATA, Unitrypa — crowded; from the close disposition of the scalæ.

STRIATA, Callopora — striated; from the numerous striæ between the cell apertures.

STRIATA, Stictopora — from the numerous striæ of the surface.

STRIATOPORA, Polypora — from the striæ between the cell apertures.

STRIATURUM, Coscinium — striated; from the striated surface.

STRICTA, Fenestella — drawn together, hence narrow; the branches are close together, and hence the fenestrules are narrow.

SUBCARINATA, Stictopora — somewhat carinated; the central ridge is stronger than the others and resembles a carina.

SUBMUTANS, Polypora — somewhat changeable; referring to the character of the frond.

SUBQUADRATA, Orthopora — somewhat square; from the subquadrangular cell apertures.

SUBRIGIDA, Stictopora — somewhat rigid; from the appearance of the frond.

SUBSTELLATA, Lichenalia — somewhat stellate; from the obscure stellate disposition of the cell apertures on the monticulæ.

SUBTILIS, Fistulipora — thin; from the extremely thin foliaceous expansion.

SUBTORTILIS, Polypora — somewhat twisted; from the appearance of the branches.

SUBTRIGONA, Lichenalia — subtriangular; from the form of the cell apertures.

TEGULATUS, Ptychonema — having layers or folds; from the corrugations of the cell apertures.

TEGULATA, Unitrypa — tiled; the scalæ have the appearance of overlapping tiles.

TENELLA, Fenestella — delicate; the frond has a very delicate appearance.

TENUICARINA, Fenestella — having a thin carina; carinæ are extremely thin.

TENUIS, Fenestella — thin, slender; from the very slender branches.

TESSELATA, Lichenalia — checkered; the polygonal elevations surrounding the cell apertures give to the surface of the frond a tesselated appearance.

TORTA, Lichenalia — twisted; from the twisted or tortuous appearance of the epitheca or base of the frond.

TORTALINEA, Orthopora — tortuous lines; from the tortuous direction of the ranges of cell apertures.

TRIANGULARIS, Fistulipora — triangular; from the triangular form of the cell apertures.

TRIFARIA, Fistulipora — three-fold, triple; referring to the three lobes of the cell apertures.

TRILOBA, Fistulipora — three-lobed; from the trilobate form of the cell apertures.

TRIPLICATA, Fenestella — triple or three-fold; referring to the three ridges on each face of the branches.

TRISERIALE, Acanthoclema — in series of three; in looking at a specimen only three ranges of cell apertures can be seen at one time.

TUBERCULATA, Fenestella — tuberculated; from the tubercles on the non-celluliferous face of the frond.

UMBILICATA, Fistulipora — having an umbilicus; from the umbilicated centers of the monticulæ.

UNILINEA, Fistulipora — one-lined; from the single elevation between adjacent cell apertures.

UNISPINA, Callotrypa — having one spine; from the single spine at the base of each cell aperture.

UTRICULUS, Lichenalia — should have been *utriculata:* utriculate having little bladders or cells; from the appearance of the interapertural surface.

VARIACELLA, Paleschara — varying cells; from the variation in the size of the cell apertures.

VARIAPORA, Fenestella — varying pores; some of the cell apertures are much larger than the others.

VENUSTA, Cœlocaulis — beautiful; from the beautiful appearance of the species.

VESICULATA, Lichenalia — having vesicles; from the numerous vesicles between the cell-tubes.

AN INTRODUCTION

TO THE STUDY OF

THE BRACHIOPODA

INTENDED AS

A HAND BOOK FOR THE USE OF STUDENTS.

PART II.

By James Hall, assisted by John M. Clarke.

1894.

THE GENERA OF THE BRACHIOPODA.

II.

BRACHIOPODA ARTICULATA.

(*CONTINUED.*)

Spirifer, Sowerby. 1815.

(Plates 23–29.)

Synonyms; *Trigonotreta*, Kœnig, 1825; *Fusella* and *Brachythyris*, McCoy, 1844.

SHELLS transversely elongate, rarely produced axially; with or without median fold and sinus. Hinge-line straight, usually forming the greatest diameter of the shell, but in some of the subdivisions of the genus, short and inconspicuous. Cardinal extremities alate, acuminate or rounded.

Surface covered with granulations, striæ, plications or costa, variously grouped on the lateral slopes and which may be present or absent on the median fold and sinus; these are crossed by concentric growth-lines which may take the form of varices or expanded lamellæ, or be modified into fimbriæ of simple or compound spines. In the subgenera MARTINIA and MARTINIOPSIS the surface is smooth except for the concentric striæ. Shell substance fibrous, generally impunctate; in the smooth species the epidermal layer is minutely pitted.

The pedicle-valve has the umbo more or less elevated over the hinge-line, the apex acute, erect or incurved. The cardinal slopes show a slight tendency to concavity or excavation, and the median portion of the valve is more or less strongly depressed by a sinus. The cardinal area is broad, flat or incurved and its surface is transversely striated; the inner shell-layers bear a series of longitudinal or vertical canals at whose marginal extremities the fibrous tissue is sometimes produced into a row of denticles, corresponding to a row of pits on the opposite valve thus forming an accessory articulation of the valves. The essential articulation is effected by means of stout, simple teeth lying at the marginal extremities of the triangular deltidial covering and supported by dental plates which are usually short, but, in rare types, may be produced even to the anterior margin of the valve. The pedicle-passage or delthyrium is usually open. Normally it is closed by a pair of deltidial plates having the form of scalene triangles, which develop from the sides of the delthyrium and meeting, inclose wholly or partially a circular or oval pedicle foramen. At normal maturity these plates become anchylosed along the median suture and form a single convex plate (the so-called *pseudodeltidium*).

The usual absence of the deltidial covering may be due either to accidental removal or to resorption with advancing growth. In the adult and senile stages of development many species, especially in the line of development to Syringothyris, form a testaceous callosity in the pedicle-cavity, thickening the umbo and extending across the delthyrium, reaching, in extreme cases, nearly to the cardinal margin.

The muscular area consists of a subtriangular pedicle-impression occupying the pedicle-cavity, and continuous with a deeply impressed oval or obcordate area, which is posteriorly situated and divisible into a narrow median adductors and broad lateral diductors, the surface of the latter being marked by radiating or racemose furrows. The posterior and anterior members of the diductors may frequently be distinguished, the former being of less extent and their surface markings somewhat different from those of the latter.

A median septum in this valve is usually absent, though not infrequently it is in a condition of incipient development, and in certain species having the aspect of Spiriferina, it forms a most conspicuous feature of the interior.

In the brachial valve the umbo is inconspicuous; a median fold corresponds to the sinus of the opposite valve. The cardinal area is narrow, and divided by a broadly triangular delthyrium. The dental sockets are narrow, moderately deep and bounded interiorly by highly developed socket walls, the extremities of which support the crural bases.

The cardinal process is a low, transverse, sessile apophysis, having its surface vertically striated; occasionally it is bipartite or it may be wholly resorbed.

The crura are long, straight and slightly divergent; their union with the primary lamellæ of the spiral ribbon is at a broadly obtuse angle. The brachial coils are directed outward and upward toward the cardinal angles of the valves, and their variation in size and direction is in keeping with the differences in the marginal outline of the shell. The number of volutions of the ribbon exceeds that in any other genus of brachiopods. There is no jugum; its position, however, is indicated by a pair of short spinous processes originating on the primary lamellæ soon after their junction with the crura, and which are directed inward with a slight convergence.

The muscular area has about the same extent as that of the pedicle-valve, though less distinctly impressed and generally more elongated. It is constituted of two pairs of adductor impressions with their surfaces radiately or palmately striated. The anterior pair are central, narrow at their posterior extremities which are embraced by the broader posterior scars.

A faint median septum is sometimes present. In some instances of importance the socket walls are supported by septa which may be considerably produced over the bottom of the valve.

In both valves the genital region is distinctly punctated, but vascular markings are rarely observed.

Type, *Anomites striatus*, Martin (1809). Carboniferous limestone.

This comprehensive genus has been divided into the following sections, based largely upon American species, though it is believed that with the addition of some equivalent division the grouping will be found generally applicable to all Spirifers.

Section I. Radiati. (Plate 23, figs. 1–15.) Typical example, *Spirifer radiatus*, Sowerby (including *S. plicatellus*, Sowerby).

Smooth, radially undulated or plicated; fold and sinus smooth; entire surface covered with fine, filiform, radiating striæ, which may be minutely crenulated or granulose.

These radiate shells may be conveniently subdivided as follows:

1. *Pauciplicati*, or those with few low plications; as *Spirifer radiatus*, Sowerby, *S. Eudora*, Hall, from the Clinton and Niagara faunas, *S. macropleura*, Conrad, from the Lower Helderberg group.

2. *Multiplicati*, or those with numerous plications; as *Spirifer Niagarensis*, Conrad, *S. asperatus*, Ringueberg, of the Niagara group; *S. Tullia*, Hall, of the Hamilton fauna; *S. Belphegor*, Clarke, of the Genesee shales; *S. mesastrialis*, Hall, of the Chemung group.

3. *Dupliciplicati;* a few Upper Silurian species having strong dichotomous plications and the filamentous surface striæ covered with asperities. Such are *Spirifer nobilis*, Barrande, from the étage E_2, and the Niagara limestone of Illinois and Wisconsin, and *S. Schmidti*, Lindström, from the Gotland limestone.

Section II. Lamellosi. (Plate 24, figs. 1–20.) Typical examples, *Spirifer perlamellosus*, Hall, *S. mucronatus*, Conrad.

Radially plicated; surface covered with numerous concentric lamellæ. In Silurian species the fold and sinus are non-plicate; the later forms usually bear a low median depression on the fold accompanied by a corresponding median ridge in the sinus.

The lamellose species are conveniently subdivided into two groups:

1. *Septati;* those having a median septum in the pedicle-valve. The septum lies between the bases of the teeth, but does not come into contact with them as in the genus Cyrtina, where the latter are supported by dental lamellæ resting on the bottom of the valve.

This character is found in an incipient condition of development in the Niagara species *Spirifer sulcatus*, Hisinger, and is a more conspicuous feature in subsequent forms, *S. perlamellosus*, of the Lower Helderberg, *S. raricosta*, of the Upper Helderberg, *S. consobrinus*, of the Hamilton group, and *S. mesacostalis*, of the Chemung group. Up to the period of the Upper Devonian, at least in American faunas, the existence of this septum in the pedicle-valve is not accompanied by a punctation of the shell-tissue nor by the union of the processes on the primary lamellæ of the spiral arms.

2. *Aseptati.* Those without a median septum in the pedicle-valve. These species are more abundantly plicated, often much more extended on the hinge than in the septate group. The lamellæ are without radial striations. The *Aseptati* group themselves naturally about two type-forms, the first, (a) *Spirifer mucronatus*, Conrad, an alate, multiplicate shell with a single low plication in the sinus and a corresponding depression on the median fold; the other, (b) *Spirifer submucronatus*, Hall, in which the fold and sinus are not plicate.

Section III. Fimbriati. (Plate 25, figs. 1–15.) Typical examples, *Spirifer fimbriatus*, Conrad, *S. lineatus*, Martin, *S. arrectus*, Hall.

Shells with few low plications or none; hinge-line not greatly extended, often shorter than the greatest diameter of the shell; dental lamellæ moderately, sometimes notably developed; a low median septum may exist in the pedicle-valve. Surface covered with concentric rows of fringes or fine spines.

This group is divided into:

1. *Unicispinei* = Delthyris, Dalman, 1828, *sensu stricto;* those species in which the concentric fimbriæ are made up of short, simple, hollow spines. These are the early fimbriate species, the type of structure not extending, so far as now known, beyond the Devonian. The shells are distinguished from the other fimbriate Spirifers by their more extended and more distinctly plicated surface and the prominent, often sharply developed fold and sinus. Their more characteristic representatives in the American Palæozoic are *Spirifer crispus*, Hisinger, and var. *simplex*, Hall, of the Niagara faunas; *S. Vanuxemi*, Hall, of the Tentaculite limestone, *S Saffordi*, *S. octocostatus*, Hall, of the Lower Helderberg group, *S. arrectus*, *S. tribulis*, Hall, of the Oriskany sandstone and *S. duodenarius*, Hall, of the Corniferous limestone. This is the (a) *S. crispus*-type.

An interesting series of forms which has had a parallel development with the *S. crispus*-type begins with the *S. bicostatus*, Vanuxem, and var. *petilus*, Hall, in the Niagara group, is repre, sented by *S. modestus*, Hall, in the Lower Helderberg group, *S. Canandaiguæ*, from the Hamilton group, and possibly, *S. urbanus*-Calvin, from a corresponding horizon in Iowa, the line terminating in (b) *S. lævis*, Hall, from the lower Portage shales.

2. *Duplicispinei* = Reticularia, McCoy, 1844; those species in which the fimbriæ are composed of large, compound, hollow spines, often or always with lateral branches. Each spine is divided medially by a vertical septum, and along this line the spine is depressed exteriorly, giving it a double barreled appearance; from each lateral margin are given off at regular intervals short spinules at right angles to the main spine. (*S. fimbriatus*, Conrad; *S. subundiferus*, Meek and Worthen; *S. hirtus*, White and Whitfield; *S. lineatus*, Martin.)

Section IV. Aperturati. (Plate 26, figs. 1–10.) Typical examples, *S. aperturatus*, Schlotheim, *S. disjunctus*, Sowerby *S. striatus*, Martin.

Forms with plications on the fold and sinus.

This may be regarded as the typical group of Spirifers as it includes the type-species, *S. striatus*, Martin. Furthermore it is the most richly represented in species and at the same time is a most compact association, not presenting any substantial variations. Its members are strongly impressed with the typical spiriferoid characters which are maintained throughout its existence, the group terminating abruptly at the close of palæozoic time. In internal structure variations are slight and unimportant. The dental lamellæ are, as a rule, inconsiderably developed, and there is no median septum in either valve.

(a) Disjunctus-type. Forms with well-developed fold and sinus, elongate hinge and elevated cardinal area; lateral plications simple, median plications dichotomous or intercalary.

(*Spirifer arenosus*, Conrad, Oriskany sandstone; *Spirifer unicus*, Hall, Corniferous limestone; *Spirifer Whitneyi*, Hall, Lower upper Devonian; *Spirifer disjunctus*, Sowerby, Chemung group.)

A subordinate division of this section is the

(1) Hungerfordi-type (=Choristites, Fischer de Waldheim, 1825), in which the fold and sinus are low, often obsolescent, the outline suborbicular and the cardinal area compressed laterally and incurved; dental lamellæ prominently developed. This type is represented by *S. Hungerfordi*, Hall, of the lower Upper Devonian.

(b) Striatus-type. Forms having a great number of duplicate lateral plications, well developed, rarely acuminate fold and sinus, and narrow, usually extended cardinal area.

(*S. striatiformis*, Meek, Waverly sandstone; *S. Logani*, Hall, Keokuk group; *S. striatus*, Martin; *S. Marcoui*, Waagen.)

(c) Imbrex-type. Alate, mucronate shells, with narrow cardinal area, fine, simple (very rarely duplicate) lateral plications, the plications on fold and sinus being of about the same size as the rest. The surface is frequently lamellose.

(*S. Newberryi*, Hall, Waverly group; *S. Marionensis*, Shumard, Waverly and Choteau groups; *S. biplicatus*, Hall, Kinderhook group; *S. imbrex*, Hall, Burlington limestone.)

(d) Suborbicularis-type. Forms with suborbicular outline, broad, low and usually simple lateral plications; the median plications are few and indistinct.

(*S. suborbicularis*, Hall, Kinderhook-Keokuk groups; *S. subcardiiformis* Hall, St. Louis group.)

(e) Orestes-type. Shells of small size, moderately extended on the hinge; lateral plications simple and usually few in number; fold and sinus angular and with a few plications, of which the median members are much the strongest. Surface usually ornamented by fine, hair like, often granulous radiating lines.

(*S. concinnus*, Hall, Lower Helderberg group; *S. Grieri*, Hall, Corniferous limestone; *S. Orestes*, Hall, lower Upper Devonian; *S. Keokuk*, Hall, Keokuk group; *S. opimus*, Hall, Coal measures.)

(f) Divaricatus-type. Species with hinge not extended, low fold and sinus; numerous fine dichotomous lateral plications not differing in size from the median plications, all of which are crossed by fine, closely set concentric lines each bearing a fimbria of short, simple spines.

(*S. divaricatus*, Hall, Upper Helderberg and Hamilton groups.)

Section V. Ostiolati. (Plate 27, figs. 1–17.) Typical examples, *Spirifer ostiolatus*, Schlotheim, *S. Oweni*, Hall.

Forms with the median fold and sinus without plications.

(*S. perextensus*, Meek and Worthen; *S. macrothyris*, Hall, Corniferous limestone; *S. Marcyi*, Hall; *S. audaculus*, Conrad; *S. granulosus*, Conrad; *S. Parryanus*, Hall; *S. asper*, Hall, Hamilton group.)

These species, in the degree of plication of the sides and the development of the muscular scars, closely resemble the members of the foregoing group. As a rule the Ostiolati are stouter shells, shorter on the hinge and more ventricose than the

Aperturati; their surface is frequently ornamented with fine granules or interrupted radiating striæ. The cardinal process is developed as a broad, thin, spreading plate, crossed longitudinally by numerous linear depressions. A feature which appears at times in other groups, but which here possesses the highest significance, is the gradual development of the callosity or transverse plate in the apex of the delthyrium. Originally, and always in the earlier species (*S. perextensus*, Meek and Worthen, *S. macrothyris*, Hall, etc.), an accompaniment of adult or senile growth, it eventually becomes a permanent character existing throughout all the later immature growth-phases of the shell. In its simpler manifestations it is a testaceous deposit extending across the delthyrium from its inner margins; as its size increases it unites the dental lamellæ, fills the rostral cavity of the valve and extends forward along the bottom of the shell between the posterior extremities of the diductor muscular bands. This is its condition as usually seen in the middle Devonian species, *S. granulosus* and *S. audaculus.*

Not infrequently this plate is less thickened and extends downward with a convex outer surface for two-thirds the length of the delthyrium, but this particular form of development occurs less often in the early species.

In all its phases it may be coexistent with the true deltidium, though the latter is rarely retained in growth-stages where the apical callosity is well developed.

Section VI. Glabrati. (Plate 29, figs. 1–3.) Typical examples, *Spirifer glaber*, Martin, *Martiniopsis inflata*, Waagen.

Forms with the surface smooth and glabrous; fold and sinus faintly developed except at the anterior margins of the valves.

The species embraced in this division have stronger differential characters than are found among the preceding groups. The shells have a very short hinge and low cardinal area, and the subcircular marginal outline causes a noticeable alteration in the orm of the spiral arms. These have their bases well forward and are extended obliquely to the rounded cardinal extremities, in their position thus approximating the form assumed by these organs in Cyrtia and Cyrtina the crura, also, and the primary lamellæ become very long.

The character of the muscular impressions is of greater importance; the broad scars of the diductors in the pedicle-valve are here reduced to very narrow dimensions, are scarcely depressed and frequently not defined, but represented only by a radiate marking of the shell. In the brachial valve the adductor scars are two narrow impressions which widen anteriorly but are not divided transversely. The surface of the shell was covered with very fine concentric lines and the epidermal layer, which is usually effaced, was minutely punctate. Faint lateral plications are sometimes visible.

These differences from the normal type of Spirifer have led many writers to adopt McCoy's term Martinia for *S. glaber* and its allies. It is evident, however, that this division of the smooth-shelled species embraces more than one subordinate type of structure; they may be divided into

1. *Aseptati* (=Martinia, McCoy, 1844). Shells in which dental lamellæ and septa are wanting.

(*S. Maia*, Billings, Corniferous limestone; *S. subumbona*, Hall, Hamilton group; *S. glaber*, Martin, Coal Measures.)

2. *Septati.* Shells in which dental plates or septa are well developed. Two groups of the septate Glabrati may be recognized:

(a) Martiniopsis, Waagen, 1883. Species with the lamellæ developed in both valves.

(*M. inflata* and *M. subpentagonalis*, Waagen, from the Productus limestone of India).

(b) ("Gen. nov.," Tschernyschew, =Mentzelia, Quenstedt, 1871(?)), Type of *Martinia semiplana*, Waagen. Shells with dental lamellæ scarcely developed, but with a prominent median septum in pedicle-valve. Mentzelia was founded upon the *Spirifer medianus* of the Muschelkalk.

Subgenus **Cyrtia**, Dalman. 1828.

(Plate 29, figs. 4–11.)

Shells like Spirifer but having a high vertical cardinal area and semi-pyramidal contour.

(Type, *C. exporrecta*, Wahlenberg. Silurian-Devonian.)

Cyrtia is the designation of a group, having a meager representation and slight morphological value.

Syringothyris, Winchell. 1893.

(Plate 30, figs. 1–11.)

Shells spiriferoid, usually large, with erect cardinal area and broad, multiplicate lateral slopes. Fold and sinus generally non-plicate. In the pedicle-valve the delthyrium is covered by a convex, imperforate plate, which is frequently absent. The dental lamellæ, more or less strongly developed, rest on the bottom of the valve, and at their anterior extremities are produced about the broad diductor impressions. They are united beneath the deltidium by a transverse plate arising from a testaceous callosity in the apex of the delthyrium. This plate is formed by the deposition of accretions to the margins of the delthyrium, which unite in the median line, the union being marked by a raised line less distinct on the upper than on the under side of the plate. From just within the lateral margins and on the inner side of the plate two processes are given off, which are curled toward each other with some irregularity, not meeting except where coalesced with the apical callosity, forming a tube which is split along its inner surface. This tube is adherent to the transverse plate as far as the latter extends, and is frequently produced beyond its termination.

Muscular scars as in Spirifer, their anterior portion being divided by a short median septum which is an extension from the apical calcareous deposit

The brachial valve is spiriferoid in all internal details. The cardinal process is broad, multistriate and supported by a short median thickening. The spirals are large, the primary lamellæ bearing a pair of short, dis crete spinous processes which represent the jugum. The shell structure is more or less distinctly and abundantly punctate. It is probable that these punctæ perforate the epidermal layer and extend to the inner lamellæ of the shell. The exterior is usually covered with a finely textile ornament which has been compared, in appearance, to "twilled cloth."

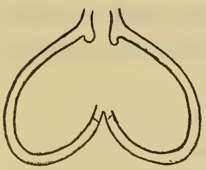


Fig. 287. The primary lamellæ of *Syringothyris typa.*

Type, *Syringothyris typa*, Winchell. Burlington limestone.

Distribution. Carboniferous.

Ambocœlia, Hall. 1860.

(Plate 31, figs. 8–17)

Shells small, concavo-, or plano-convex. Marginal outline nearly semi-circular. Hinge-line long and straight, its length nearly or quite equaling the greatest transverse diameter of the shell.

Pedicle-valve greatly elevated; umbo arched and incurved; with a narrow median groove which becomes fainter or disappears toward the anterior margin. Cardinal area well defined and arched; divided medially by an open delthyrium whose lateral margins bear incomplete deltidial plates. Teeth prominent, erect, strongly recurved at the tips; not supported by dental plates. Muscular area quite restricted, consisting of narrow, elongate diductors, inclosing an almost linear adductor. The entire area is sometimes divided by a faint median ridge. The interior surface about the muscular area is strongly pitted.

Brachial valve convex at the beak, becoming depressed over the pallial region and reflexed near the margin. Cardinal area comparatively broad and standing at nearly right angles to the area of the opposite valve. Delthyrium open, the deltidial covering attaining the same degree of development as in the pedicle-valve. Cardinal process narrow and much elongated, resting on the bottom of the valve except at its posterior extremity, which is simply bifurcated. Crural plates erect, parallel; taking their origin in the deltidial plates and extending about one-fourth the distance across the valve. The spirals are attached by long crura, the ribbon making a few volutions only, thus forming loose coils, directed laterally. The jugum has apparently the same incipient condition of development as in Spirifer. According to Œhlert, the spiral ribbon bears spinules on its outer margins. Muscular impressions anterior and composed of four well-defined adductor scars.

Surface smooth or with fine concentric striæ crossed by indistinct radiating lines; rarely spinous. Shell substance fibrous, impunctate.

Type, *Ambocœlia umbonata*, Conrad (sp.), Hamilton group.

Distribution. Devonian — Carboniferous.

Metaplasia, Hall. 1893.

(Plate 31, figs. 21–24.)

Shells spiriferoid in exterior, with the relative convexity of the valves reversed, the pedicle-valve bearing a median fold and the brachial valve a broad median sinus.

The teeth are stout and unsupported by lamellæ; the posterior extremities of the diductor impressions in the pedicle-valve are deeply impressed and separated by a short, thick septum. Anteriorly the muscular area is less clearly defined; from its distal margin diverge two ridges which were probably of vascular origin, and a few radiating furrows of similar character are seen on the lateral portions of the valve.

In the brachial valve the cardinal process is quite prominently developed and is distinctly bilobed. The socket walls are elevated and recurved; anteriorly they are produced into short crural bases which are not free, but rest upon the bottom of the valve. The muscular area is narrow and elongate and consists of a pair of central adductor scars embraced posteriorly by a broader pair. From the anterior margin of this area arise two vascular trunks which diverge outwardly and recurve, following the margins of the valve. These give off a series of branches externally and probably a shorter series toward the center of the valve. The ovarian markings are very distinct about the bases of the dental sockets. Brachial supports unknown.

The external surface of the shell is smooth or covered with very fine concentric lines. The shell substance is fibrous and apparently impunctate.

Type, *Metaplasia pyxidata*, Hall (sp.). Oriskany sandstone.

But a single species is known.

Verneuilia, Hall. 1893.

(Plate 31, figs. 18–20.)

Shells spiriferoid with a deep median sinus on each valve. The exterior of the valves is divided by two strong divergent ridges into three depressed areas.

Type, *Verneuilia chiroptyx*, d'Archiac and de Verneuil (sp.) Middle Devonian.

Distribution. Devonian — Carboniferous.

Cyrtina, Davidson. 1858.

(Plate 29, figs. 12–26.)

Shells usually of small size and semi-pyramidal contour. Pedicle-valve with a high, vertical or arched cardinal area, which may be unsymmetrical from distortion or unequal lateral growth; this area is divided medially by an elongate-convex deltidium, which may be perforated at any point below the apex, by a circular, direct or oblique foramen, or be without any evidence of such foramen. When present the foramen is accompanied by a sinus on the deltidium, extending from it to the apex of the valve; even when this foramen has been closed from senile deposition of testaceous matter this foraminal groove may remain.

The exterior surface bears a median sinus and more or less distinct lateral plications. On the interior the dental lamellæ are strongly developed and converge rapidly, meeting a median septum from the bottom of the valve. The union consists of a lateral junction of the dental lamellæ with the septum, the latter continuing for a short distance beyond the point of confluence as a vertical ridge, always apparent in the bottom of the spondylium thus formed. At the point of union these three plates constitute a tubular chamber which has no external opening in older shells, and may be filled by organic deposit. The dental plates are shorter than the septum, the latter, at its base, extending beyond the center of the valve, its anterior margin being concave and its inner extremity acute and produced.

Brachial valve very shallow, with narrow, inconspicuous cardinal area. Surface plicated as in the opposite valve. Cardinal process consisting of a double apophysis on the sides of which are strong, divergent crural plates. The spiral cones are elongate-fusiform, each coil attaining its greatest diameter just below the center. They are directed obliquely upward and backward toward the middle of each lateral slope of the pedicle-valve. The jugum is continuous, its branches being directed upward and forward, uniting at their extremities. The muscular impressions comprise two oval anterior, and fainter posterior scars. The surface ornamentation consists of radial plications which may cover both fold and sinus; in rare instances the lateral plications are absent. The concentric growth-lines are sometimes fine and crowded, at others distant and lamellose; occasionally the surface is coarsely papillose. Shell substance strongly punctate.

Type, *Cyrtina heteroclita*, Defrance. Middle Devonian.

Distribution. Silurian — Lower Carboniferous.

Bittnerula, gen. nov.

Shells small, cyrtiniform; exterior smooth, substance highly punctate. Umbo of the pedicle-valve deformed or cicatrized, evincing attachment in early growth stages. Interior of the pedicle-valve with a short median septum, attached to the valve for one-fourth the length of the latter, becoming free and

Figs. 288–292. *Bittnerula Zitteli*, Bittner (sp.). (Bittner.)

elevated toward its anterior extremity. This septum rises almost to the delthyrium where it joins two greatly abbreviated dental plates which thus form a transverse platform beneath the deltarium.

Type, *Bittnerula Zitteli*, Bittner (sp.)

Distribution. Trias.

Spiriferina, D'Orbigny. 1847.

(Plate 31, figs. 1–7.)

Shells resembling Spirifer in external aspect; interiorly the pedicle-valve bears a median septum resting upon the bottom of

Fig. 293. The jugum of *Spiriferina Kentuckiensis*, Shumard.

the valve, its posterior portion lying between, but not united with the strong dental lamellæ. The process on the primary lamellæ are continuous, forming a simple transverse or subacute jugum.

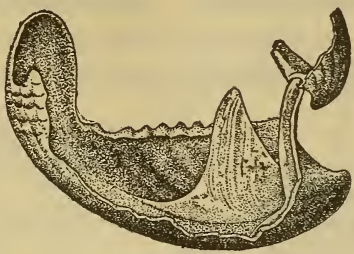
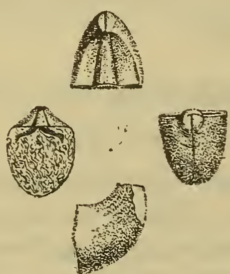


FIG. 294. *Spiriferina Walcotti.* Sowerby; showing muscular scars on walls of median septum of pedicle-valve.

Shell substance strongly punctate throughout.
Type, *Spiriferina rostrata*, Schlotheim (sp.). Lias.
Distribution. Devonian (?) —— Jurassic.

Thecocyrtella, Bittner. 1862.

Synonym; *Cyrtotheca*, Bittner, 1890.
Minute shells similar to CYRTINA in exterior and interior, but attached by the apex of the pedicle-valve. Surface smooth.

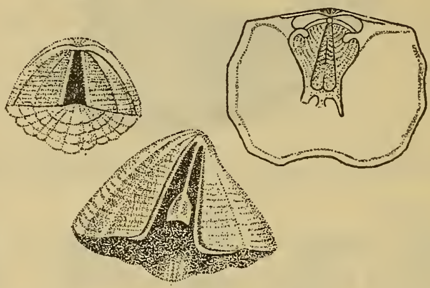


FIGS. 295–298.—Internal casts of *Thecocyrtella ampezzana*, Bittner, sp. (BITTNER.)

Type, *Thecocyrtella ampezzana*, Bittner.
Distribution. Triassic.

Suessia, Deslongchamps. 1854.

Shells, cyrtiniform, with high, often arched cardinal area; deltidial covering absent or lost. Surface plicate, with median fold and sinus on brachial and pedicle-valves respectively. On the interior of the pedicle-valve are two small dental plates which do not extend to the bottom of the valve. Between these arises a large median septum which is horizontally expanded at its summit and toward its interior margin. In the brachial valve the dental sockets are deep, the hinge-plate very large, formed by the horizontal expansion and union of the crural plates and producing a plat-



Figs. 299–301. — *Suessia costata*, Deslongchamps; showing the structure of the pedicle and brachial-valves. (Suess.)

form which extends to the middle of the valve. This plate bears the impressiom of the adductor muscles. The primary lamellæ of the spiral coils are united by a jugum bearing a median process directed anteriorly.

Type, *Suessia costata*, E. Deslongchamps.

Distribution. Jurassic.

Whitfieldella, Hall. 1893.

(Plate 32, figs. 1–9.)

Shells usually of small size; valves subequally convex, ovate or elongate in outline. Umbo of the pedicle-valve not high or greatly incurved, usually exposing the circular apical foramen, beneath which the deltidial plates are frequently retained. Cardinal slopes of both valves broad and not distinctly defined; anterior margin subtruncate and gently sinuate. In the typical forms there is a faint sinus on both valves near the anterior margin, otherwise the surface is smooth. On the interior the muscular impressions of the pedicle-valve are similar to those of Meristella. In the brachial valve the hinge-plate is concave, divided by a deep central concavity which is supported by a median septum. On either side are lobes bearing the bases of the crura. The brachidium consists of two spiral cones arranged as in Merista, but as a rule the ribbon makes fewer (from six to twelve) volutions at maturity. The jugum is simple, the branches being more nearly erect than in Merista, Meristella, etc., and

Figs. 302, 303.—The jugum of *Whitfieldella nitida*, Hall.

beyond their junction continued into a short, acute, generally slightly curved process, which makes a large angle with the direction of the lateral branches. The muscular impressions, which are very faint, are divided, longitudinally, by the median septum, and transversely, into anterior and posterior scars. From the ante-lateral margins of the muscular area in both valves radiates a series of vascular sinuses, the principal trunks of which are very conspicuous; this feature, however, is rarely retained. External surface of the valves smooth or concentrically striate. Shell-substance fibrous, impunctate.

Type, *Whitfieldella nitida*, Hall, (sp.). Niagara group.

Distribution. Upper Silurian — Lower Devonian.

Hyattella, Hall. 1893.

(Plate 32, figs. 10–17.)

Shell compactly subpentahedral; the umbo of the pedicle-valve acute, concealing most of the deltidial covering. The pedicle-valve bears a strong median sinus and two faint lateral sinuses, the opposite valve having corresponding folds. The surface of the shell and the ante-lateral margins are deeply sinuate. Fine, sharp, closely crowded concentric striæ cover the exterior.

Fig. 304.—The loop of *Hyattella congesta*, Conrad.

The interior of the pedicle-valve has a deep and strongly striate pedicle-cavity, bounded by strong dental lamellæ; the diductor scars are distinctly defined, inclosing a linear adductor. In the brachial-valve the hinge-plate is triangular and divided medially by a deep cleft. The lateral portions are broad and elevated, supporting short, straight crura. The spiral ribbon makes not more than six volutions, forming very loose coils. There is no median septum.

Type, *Hyattella congesta*, Conrad (sp.).

Distribution. Middle Silurian.

Dayia, Davidson. 1881.

(Plate 32, figs. 21–25.)

Shells small, subtrihedral in contour, with a very convex pedicle-valve which may be obscurely keeled along the middle and depressed laterally. Brachial valve convex posteriorly, but becoming concave over the anterior region, and bearing a well-developed median sinus. The hinge-line is short; the cardinal area absent. The umbo of the pedicle-valve is gibbous and its apex closely incurved, concealing the foramen. Deltidial plates were probably developed, but they appear to be invariably lost in separated valves. The delthyrium is wide, the teeth divergent, moderately conspicuous and unsupported by lamellæ. In the bottom of the valve are two narrow, divergent muscular grooves, bordered on their anterior edges by thickened ridges, both having the shape of a broad inverted V.

In the brachial valve the character of the hinge-plate was probably simple, and supported by a median septum traversing about one-half the length of the valve; on either side of this septum are the lateral members of the adductor impression. The crura are short and straight; the primary lamellæ are attached to them by a subrectangular curve and pass outward just within the margin of the valve. The spirals are but slightly elevated and have their apices directed outward toward the lateral slopes of the opposite valve. The ribbon makes but three or four turns, and its outer anterior edges are quite coarsely fimbriated. The jugum is situated anteriorly, taking its origin near the upward turn of the primary lamellæ; it is directed upward and backward, the lateral processes meeting at or just behind the center of the interior cavity. From the point of union proceeds a short, simple process, which does not make an angle with the rest of the jugum.

Type, *Dayia navicula*, Sowerby (sp.). Wenlock limestone.

But one species has been recognized.

Hindella, Davidson. 1882.

(Plate 32, figs. 18–20.)

Shells subcircular or elongate-ovate in outline; valves convex, the pedicle-valve being gibbous in the umbonal region. The hinge-line is very short but the cardinal slopes are frequently long and transverse, which, with the fulness of the beaks of both valves, produce a "shouldered" appearance. There is a low sinus on the pedicle-valve which is apparent only over the pallial region; this is accompanied by a slight fold on the opposite valve.

The apex of the pedicle-valve is closely incurved, concealing both deltidial plates and foramen. On the interior the teeth are moderately prominent and are supported by strong dental plates,

Figs. 305, 306. The primary lamellæ and jugum of *Hindella umbonata*, Billings (sp.).

which not only extend to the bottom of the valve, but are continued forward for about one-third the length of the shell, and inclose a narrow, elongate muscular area. In the brachial valve the hinge-plate appears to be short and constructed on the same plan as that of Meristina and Whitfieldella, with two diverging crural bases divided by a median groove, or a subtriangular pit, and is supported by a median septum extending for about one-half the length of the valve. Spirals everted; jugum situated anteriorly, very depressed, the lateral processes being directed backward in a low upward curve, uniting to form a short, straight undivided stem. External surface smooth. Shell-structure fibrous, impunctate.

Type, *Hindella umbonata*, Billings (sp.).

Two species are known, both from the Middle Silurian.

Meristina, Hall. 1867.

(Plate 33, figs. 1–7.)

Synonym; *Whitfieldia*, Davidson, 1882.

Shells biconvex, the greatest depths of the valves being subequal. General expression meristoid. The beak of the pedicle-valve is erect in youth, but so greatly incurved at maturity as to totally conceal the foramen and deltidium. Cardinal slopes narrow but distinct, forming prominent shoulders which may be traced nearly to the middle of the lateral margins. A low, often indistinct median ridge extends from the apex forward; at about the middle of the shell it is divided by a faint groove, becoming broader toward the margin and continued into a subnasute extension. Lateral slopes scarcely depressed.

The brachial valve also bears a low median ridge, which manifests itself most conspicuously over the anterior portion of the shell.

On the interior of the pedicle-valve the teeth are conspicuous and are supported by thin plates, which extend to the bottom of the valve and are produced forward to form the lateral boundaries of the muscular area. Between the posterior portion of these plates lies the deep scar of the pedicle-muscle, which is separated from the elongate and radially striate diductor impression by a prominent callosity.

In the brachial valve the hinge-plate is deeply divided in the middle by a narrow sulcus, the two lateral lobes being elevated, and supporting the crural bases. The plate is thickened on the under side and supported by a median septum, which extends for one-half the length of the valve. The crura are short and straight, and the primary lamellæ of the spiral ribbon originate from them at a sharp angle, diverge laterally as they turn downward, passing over a portion of the secondary volutions, approach each other toward the middle of their length, nearly meeting at the anterior edge of the median septum, thence again diverging to their anterior recurvature. The secondary volutions do not follow precisely the curvature of the primary lamellæ and the resultant cones at maturity have a gracefully undulated surface. The jugum consists of two lateral branches, broad at their origin, inclined backward, and uniting to form a stem which bears a short bifurcation at its extremity.

The muscular area is elongate-ovate and more or less distinctly separated into anterior and posterior scars. Surface of the valves smooth or with fine concentric growth striæ. Shell-substance fibrous, impunctate.

Type, *Meristina Maria*, Hall. Niagara group.

Distribution. Silurian.

Glassina, Hall. 1893.

Shells small, biconvex, smooth. Spirals everted; jugum forming neither athyroid saddle nor upright stem, but giving off at the junction of the lateral branches two linear processes; the whole apparatus having thus the form of an inclined ×, with its upper tips curved outward.

Type, *Glassina læviuscula*, Sowerby (sp.). Wenlock limestone.

But one species has been recognized.

Merista, Suess. 1851.

(Plate 33, figs. 8–15.)

Synonym; *Camarium*, Hall, 1859.

Shells transverse or elongate, both valves generally inflated; anterior margin sinuate, producing a fold and sinus on the marginal portion of the brachial and pedicle-valves respectively.

In the pedicle-valve the apex is perforated by a circular foramen, which, however, is usually concealed at maturity, by the incurvature of the beak; deltidial plates rarely retained. On the interior the teeth are prominent and are supported by dental plates which extend either for a short distance into the interior cavity or are considerably produced at their bases as thickened ridges. Between the dental plates is an arched free plate (the "shoe-lifter" process) attached by its posterior and lateral margins, but at its anterior margin extending beyond the dental lamellæ and rising in a low, broad curve. In rare instances this process, from its origin, bears a sharp median carina which makes the anterior margin highly angulate. The muscular area appears to be limited to the space between the dental lamellæ and to the surface of the "shoe-lifter."

In the brachial valve a median septum is more or less strongly developed and divides a simple ovate adductor impression. The hinge-plate is short and deeply divided by a median groove. The brachial supports consist of spiral cones with their bases in apposition and parallel to the axial plane of the shell, and their apices directed toward the lateral margins. The jugum has been shown by Glass to have the following structure: The lateral branches approach and unite near the middle of the interior cavity, forming a very short stem, from the posterior extremity of which is given off a pair of arms. These curve

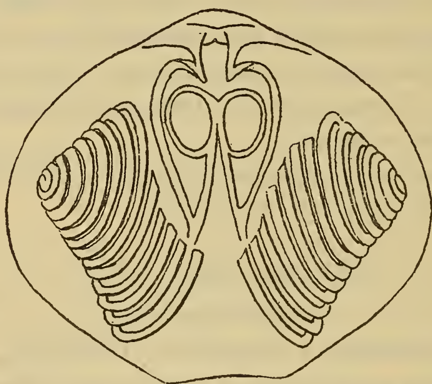


Fig. 307.—The spirals and jugum of *Merista herculea*, Barrande. (Davidson, from a preparation by Glass.)

downward to the primary lamellæ of the coil and returning meet the lateral branches below their point of union, the whole forming a scissors-shaped arrangement essentially like that of Meristella, differing only in minor respects indicated under the discussion of that genus.

External surface of the valves smooth or with concentric growth-lines. Shell-substance fibrous.

Type, *Merista herculea*, Barrande. Etage E.

Distribution. Upper Silurian.—Devonian.

Dicamara, Hall. 1893.

(Plate 33, figs. 16–19.)

Meristoid shells with a "shoe-lifter" in each valve; that of the brachial valve being divided by a vertical median septum.

Type, *Dicamara plebeia*, Sowerby (sp.).

Distribution. Devonian.

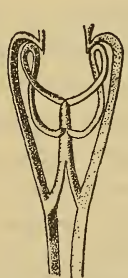
Meristella, Hall. 1859.

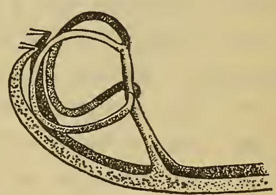
(Plate 34, figs. 1–11.)

Shells having the same general external characters as Merista. Valves convex, often inflated, cardinal areas obscure. The umbo of the pedicle-valve is incurved at maturity, concealing most, if not all, of the foramen; in early stages of growth, however, the beak is more erect and exposes the deltidial plates in an elementary condition of development. The anterior margin of the shell is sinuate, and usually there is a sinus on the pedicle-valve, with a less conspicuous fold on the brachial valve; sometimes both valves bear a low sinus, or the sinus on the pedicle-valve may be absent, while the fold on the brachial valve is present, thus giving the shell a nasute anterior extension; again, fold and sinus may be absent on both valves.

In the interior of the pedicle-valve the delthyrium is wide, its margins being thickened into dental ridges. The teeth are conspicuous, often much thickened and curved backward at their tips, interlocking with the opposite valve in such a manner as to make a very firm articulation. The teeth are supported by lamellæ which rest upon the bottom of the valve and are continued for a short distance about the posterior margin of the muscular impression. In old shells this portion of the valve becomes greatly thickened, the muscular impression correspondingly deepened and the identity of the dental lamellæ is obscured by their becoming merged with the substance of the valve. The pedicle-cavity is deep and frequently shows a strong muscular scar. The impression of the diductor muscles is subquadrate-ovate or subtriangular in outline, very strongly impressed and usually clearly divisible into its two lateral components. The central adductor scar is faint, but linear when retained. The lateral scars are deeply striated longitudinally. The anterior margin of the muscular area is frequently obscure but is not infrequently a ridge from which radiate fine, anastomosing pallial sinuses. In the post-lateral regions the ovarian sinuses are sometimes retained.

In the brachial valve the beak is depressed and sometimes obscured by the incurvature of the umbo of the opposite valve. The dental sockets are narrow and divergent. The hinge-plate is subject to some unessential variation in form. Usually it is triangular, concave on the upper surface and divided into two lobes by a median groove. The crura take their origin from just within the anterior margins of the lobes thus formed. In some species the hinge-plate is more subquadrate in outline, the variation being produced by the development of post-lateral expansions. This plate is supported by a median septum, which extends for somewhat more than one-third the length of the valve. The crura are short and straight, and the primary lamellæ of the brachidium originate from them at an acute angle, and come into closest apposition at the anterior extremity of the median septum. In the mature individual, the spiral ribbon makes about fifteen volutions, the bases of the cones being subparallel to the longitudinal axis of the shell and their apices directed toward its lateral margins. In their general shape the





Figs. 308, 309 —The jugum of *Meristella Walcotti.*

cones conform to the character of the interior cavity, and in the less convex species (*M. Walcotti*, *M. lenta*), they are appressed on the side of the flatter or brachial valve. The structure of the jugum is the same as described for the genus Merista, with this difference, however: the circular arms of the jugum curve first outward in the horizontal plane, then backward and abruptly downward to the inner edges of the primary lamellæ; in their return the same curvature is reversed and they, therefore, meet the stem of the jugum in the horizontal plane, their point of union being invariably above the point of coalescence of the lateral branches of the jugum.

The muscular area is elongate-ovate, and extends for the entire length of the median septum; the four adductor scars are sometimes distinctly seen, the posterior pair being broader and embracing the posterior extremities of the anterior scars.

External surface of the valves smooth or with concentric striæ. Shell-structure fibrous, impunctate.

Type, *Merista lævis*, Hall. Lower Helderberg group.

Distribution. Devonian.

Dioristella, Bittner. 1890.

Smooth shells having a jugum whose lateral branches return upon themselves, somewhat as in Meristella.

Fig. 310.—Jugum of *Dioristella indistincta*, Beyrich (sp.). (Bittner.)

Type, *Dioristella indistincta*, Beyrich (sp.).

Distribution. Triassic.

Charionella, Billings. 1861.

(Plate 34. figs. 12–14.)

Shells meristoid in exterior and probably in the structure of the brachidium and jugum. Hinge-plate greatly modified, its appearance being that of two ridges, strongly recurved at their edges, passing along the margins of the delthyrium and inclosing the dental sockets; these are supported by thin lamellæ which converge toward the bottom of the valve; the crura arising from the extremities of the lateral ridges are short and curved outward; the central portion of the plate must be considered as absent, or as very concave and merged in the substance of the valve.

Type, *Charionella scitula*, Hall (sp.) Corniferous limestone.

Pentagonia, Cozzens. 1846.

(Plate 34, figs. 15–20.)

Synonym; *Goniocœlia*, Hall, 1861.

Shells with a very broad sinus on the pedicle valve, which is limited by divergent carinæ, outside of which the cardinal or lateral slopes are very abrupt. On the brachial valve is a rounded median fold, which may be divided on its summit by a narrow sinus, and in the umbo-lateral region are two short folds or flanges, beginning at the hinge-line, having a slightly sinuous curve and terminating before traversing much more than one-third the length of the valve; occasionally there is a second of these ridges on each side.

The muscular impressions of the valves are essentially as in Meristella. The hinge-plate has a peculiar structure; it arises vertically from the bottom of the valve, presenting an erect, concave anterior face, which is traversed by a faint median ridge continuous with the septum of the valve. The posterior portion of the upper surface of this plate bears a deep circular or crescentic concavity, most sharply defined on its anterior edge where it is bounded by the somewhat recurved vertical wall. On the lateral portions of the upper face of the anterior wall lie the elongate crural bases which are continued into short, straight crura, standing at an angle of about forty-five degrees to the plane of the horizontal face of the plate. The spiral cones are as in Meristella, their curvature conforming to the peculiarly contracted interior cavity of the shell. Precise nature of the jugum not known.

Type, *Pentagonia unisulcata*, Conrad (sp.).

Distribution. Devonian (Upper Helderberg and Hamilton groups).

Camarospira, Hall. 1893.

(Plate 33, figs. 20–23.)

Shells essentially meristelloid in external and internal characters. The important difference from allied genera lies in the fact that the dental plates of the pedicle-valve, instead of resting upon the bottom of the valve, are more strongly convergent than in Merista, Meristella, etc., uniting before they reach the internal surface of the valve, thus restricting the impression of the pedicle-muscle to a distinct chamber or spondylium, which is supported by a low median septum. In the typical species this chamber has the same extent as the deep pedicle-cavity in Meristella, that is, about one-fourth the length of the valve, while the septum extends for a short distance beyond its anterior margin, dividing the scars of the adductor and diductor impressions. In this respect the internal structure of this valve is similar to that of the corresponding valve of Pentamerus.

In the brachial valve the hinge-plate is supported by a median septum slightly longer than that of the opposite valve, and the narrow, cordate muscular impression, which it divides medially, is considerably thickened. The valve bears everted spirals similar to those of other members of this group, but the specimens studied were not in a condition of preservation adapted to the determination of the structure of the jugum.

Type, *Camarospira Eucharis*, Hall. Corniferous limestone.

Athyris, McCoy. 1844.

(Plate 35, figs. 1–8.)

Synonyms; *Spirigera*, D'Orbigny, 1847; *Euthyris*, Quenstedt, 1871.

Shells subequally biconvex; outline transversely elliptical, subcircular or elongate-subovate; surface medially sinuate.

In the pedicle-valve the umbo is inconspicuous and incurved, usually concealing the foramen and deltidial plates; frequently, the former is exposed. Cardinal slopes not well defined in the typical group. The convexity of the valve is greatest in the umbonal region, the surface sloping evenly to the sides, and becoming depressed on the median line into a sinus, which is most prominent on the anterior margin. Beak of the brachial valve not prominent; a median fold corresponds in strength to the sinus of the opposite valve.

In the interior of the pedicle valve the deltidial plates are usually absent; the teeth are prominent, recurved at the tips, and supported by stout dental lamellæ, which are not produced anteriorly about the muscular area. Between them lies a deep, transversely striated pedicle-cavity, and in front of this an ovate muscular scar extending about one-half the length of the valve and divided into flabellate diductors (which are frequently very indistinct) and narrow, cordate adductors. The pallial region is covered with ovarian pittings and branching sinuses.

In the brachial valve the dental sockets are broad and deep. The hinge-plate varies considerably in form; in the typical division of the genus it is subtriangular in outline, and supported by stout crural plates. The median portion is flat or concave, the lateral margins thickened and elevated. At the apex of the plate and just within the beak of the valve is a circular perforation (visceral foramen), which is continued beneath the plate into the cavity of the valve. The anterior margin of the plate is straight or slightly concave, occasionally trilobate, and the crura are attached at the extremities of the lateral ridges. Sometimes the outline of the hinge-plate is rendered subquadrate by the development of two post-lateral expansions.

The brachidium consists of spiral cones lying base to base, with their apices directed laterally. The form of these cones varies with that of the internal cavity, but as a rule they are much compressed vertically, the posterior curvature being short and convex,

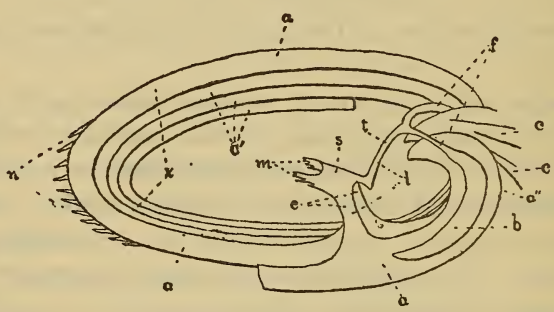


Fig. 311.

Diagram of the structure of the brachidium in Athyris.

x. Spiral coil.
a. Primary lamellæ of spiral coil.
a′. Secondary lamellæ.
a″. Umbonal blades.
c Crura.
l. Jugum.
e. Lateral branches of jugum.
s. Saddle.
m. Fimbriated extensions of saddle.
t. Stem of jugum.
f. Arms of jugum.
b. Accessory lamellæ.
n. Fimbriæ on outer margins of lamellæ.

while the anterior curve is long and sometimes depressed. The crura originate from the hinge-plate at a large angle, are long and convergent, the primary lamellæ beginning at their extremities, making an angular curve at their origin, thence, in the typical species, curving deeply upward and backward, to form the first volution. The spirals are connected by a jugum, which takes its origin on the first half of the primary lamellæ, the two lateral lamellæ converging, and uniting at about half the distance across the base of the cones, to form a broad saddle with a convex upper surface; the anterior extremity of this saddle may be simple or divided; its posterior portion is narrowed, inclined downward or toward the beak of the brachial valve for a short distance, thence it rises abruptly toward the umbo of the pedicle-valve, and bifurcates near the extremities of the crura, each branch following the curvature of the primary lamellæ and continuing for only a part of the distance between the ends of the crura and the origin of the jugum. These accessory lamellæ vary somewhat in form, are narrower than the ribbon of the coil, and lie between the primary, and the first band of the secondary lamellæ.

The muscular area consists of a long, ovate scar, which is divided into a subquadrate posterior pair, and a subcordate anterior pair of adductor impressions. These are separated longitudinally by a very faint median ridge. On casts of the interior the filling of the visceral foramen in the hinge-plate frequently shows a cross-striation like that of the pedicle-cavity of the opposite valve, and also indicates that the median ridge is continued throughout the extent of this passage.

The surface of the valves is variously ornamented; in the typical group, at each concentric growth-line, there is a broad lamellar expansion; in some cases this expansion is striated longitudinally, or it may be divided into flat spines, which merge into the lamella at their bases; again the spines may be long and tubular, but connected by the laminar expansions. The surface frequently appears to be smooth or covered only with concentric striæ, and in one of the largest subdivisions of the genus (Seminula) it is a normal condition, while in other divisions it is often wholly casual.

Shell-substance fibrous, impunctate.

Type, *Athyris concentrica*, von Buch (sp.). Middle Devonian.

Distribution. Upper Silurian (?) — Carboniferous.

Subgenus Cliothyris, King. 1850.

(Plate 35, figs. 9, 10.)

Shells with surface ornamentation consisting of broad, thin, lamellar expansions, which are divided almost, sometimes quite to their bases into long, flat spinules; the hinge-plate is narrow and rather acutely triangular; the primary lamellæ are attached to the crura not only at their apices but for a short distance along their inner faces, not making the nooses peculiar to ATHYRIS proper; they are broad and blade-like, narrowing beyond the insertion of the jugum; the jugum is situated posteriorly; the accessory lamellæ are narrow near their origin, broaden and then taper again, having the shape of a sickle. The spiral ribbon

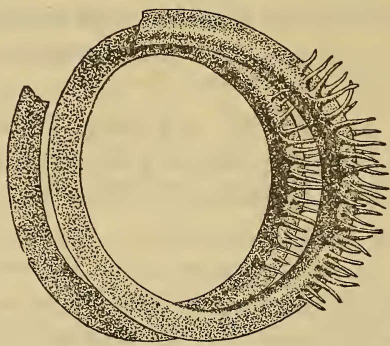


FIG. 312.—The fimbriated spirals of *Cliothyris pectinifera*, Sowerby (sp.). (DAVIDSON.)

appears, from the figures given by DAVIDSON and KING, to be pectinated on all its outer edges, but it has not been shown that the anterior extremity of the jugum is similarly ornamented

(Type, *Cliothyris pectinifera*, Sowerby (sp.). Lower Carboniferous — Permian.)

Subgenus **Actinoconchus**, McCoy. 1844.

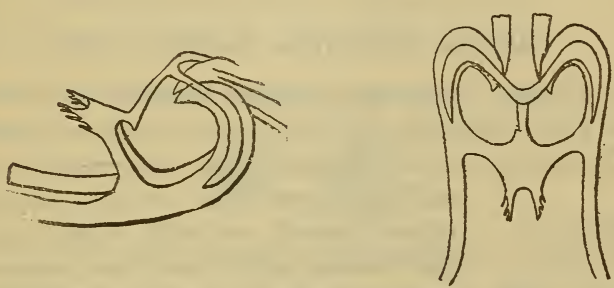
Shells characterized by the extravagant development of the concentric lamellar expansion, which are striated radially by distant sulci. These expansions appear to be actually fine, tubular spines connected by, or imbedded in a tenuous calcareous plate. The interior of the pedicle-valve bears a median septum which traverses the pedicle-cavity and half the length of the shell; also two strong dental plates which are continued forward, slightly diverging, for more than one half the length of the septum. Mr. DAVIDSON has given elaborate illustrations of the spirals and loop of this species, from preparations by the Rev. NORMAN GLASS, and from them it appears that the latter organ, the jugum, has essentially the same conformation as in *Cliothyris pectinifera*, though placed further forward. The saddle of the jugum is neither divided nor pectinated, while the spiral ribbon bears short spinules on the edge and face of the lamellæ fronting the sides of the shell.

(Type, *Actinoconchus planosulcatus*, Phillips (sp.). Carboniferous.)

Subgenus Seminula, McCoy. 1844.

(Plate 35, figs. 11–19.)

Shells transverse, often elongate or ficiform; valves biconvex, the pedicle-valve with a median sinus over the pallial region, and the brachial valve with a corresponding ridge; both sinus and fold may be divided by a sharp median sulcus extending from the umbones to the margins. There is frequently evidence of a single obscure lateral fold on each side of both valves. The umbo of the pedicle-valve is incurved and the deltidial area is usually concealed; the foramen, however, is exposed



Figs. 313, 314.—The jugum of *Seminula subtilita*, Hall.

as a circular or ovate aperture which encroaches on the substance of the valve. In the pedicle-valve the diductor muscular impressions are very faintly defined; the adductor and pedicle impressions are as in the typical forms of Athyris. In the brachial valve the hinge-plate is highly developed, its upper face being subquadrate in outline, concave on the surface, the concavity deepening toward the visceral foramen which lies just beneath the beak; not infrequently the foramen is closed by secretions of testaceous matter. The posterior flanges of the plate pass beyond the hinge-line and into the umbonal cavity of the opposite valve. The anterior face of the plate is erect and the anterior edge somewhat trilobed, the lateral lobes bearing the crural bases. The crura are straight and their attachment to the primary lamellæ is of the same character as in Cliothyris, etc. The primary lamellæ, on the umbonal curve, are broad, the jugum usually situated posteriorly. The saddle of the jugum is often bilobed on its anterior margin, and frequently both it and the outer margins of the ribbon of the secondary volutions are fimbriated.

The muscular impressions of this valve are very narrow, and subdivided into two pairs of elongate scars. The members of the posterior pair are divided by a median septum or ridge, which begins beneath, though it does not support the hinge-plate. Branching vascular sinuses are sometimes retained over the pallial region of both valves.

Surface of the valves smooth, that is, with sharp, concentric striæ which were never produced into lamellæ.

(Type, *Seminula ambigua*, Sowerby (sp.). Carboniferous.)

Subgenus Spirigerella, Waagen. 1883.

Shells elongate transverse; contour showing a decided tendency to plano-convexity, the pedicle-valve being depressed by a broad, flat sinus, and the brachial valve considerably elevated; cardinal slopes more or less pronounced; surface smooth or with sharp, concentric growth-lines, which were not produced into lamellæ or spines. On the interior the hinge-plate is high, the anterior face being erect, the upper face subquadrate in outline and concave, the posterior face extending considerably beyond the hinge; it is perforated by a visceral foramen. The jugum is situated pretty well back and its structure is essentially like that in *Actinoconchus planosulcatus;* in *S. Derbyi*, however, the saddle of the jugum, which is entire on its anterior margin, bears a median septum on its summit, extending from its anterior edge to the bifurcation of the stem; a feature not elsewhere observed among the athyroids, except in Kayseria.

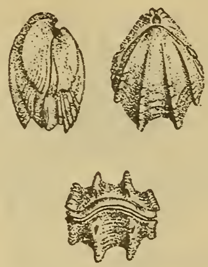
Fig. 315.—Jugum of *Spirigerella Derbyi*, Waagen. (Waagen.)

(Type, *Spirigerella Derbyi*, Waagen. (?) Carboniferous.)

Tetractinella, Bittner. 1890.

Synonym; *Plicigera*, Bittner, 1890.

Shells with four corresponding ribs on each valve; spiral cones directed laterally; jugal branches erect, uniting in an elongate



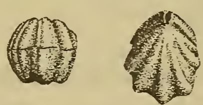
FIGS. 316–318 — *Tetractinella trigonella*, Schlotheim (sp) (BITTNER).

narrow and nearly vertical saddle from the posterior extremity of which short intercalary lamellæ are given off.

Type. *Tetractinella trigonella*, Schlotheim (sp.).

Distribution. Triassic.

Subgenus Pentactinella, Bittner. 1890.

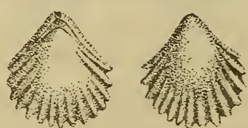


FIGS. 319, 320.—*Pentactinella quinquecostata;* Münster (sp.). (BITTNER)

Shells with five corresponding ribs on each valve. Interior as in TETRACTINELLA.

(Type, *Pentactinella quinquecostata*, Münster (sp.). Triassic.)

Subgenus Anomactinella, Bittner. 1890.



FIGS. 321, 322.—*Anomactinella flexuosa*, Münster (sp.). (BITTNER.)

Shells with a number of ribs sharply developed toward the margins. Interior probably as in TETRACTINELLA.

(Type, *Anomactinella flexuosa*, Münster (sp.). Triassic.)

Amphitomella, Bittner. 1890.

Smooth shells with a very strong double cardinal process, and a median septum in each valve extending the entire length of the shell and dividing the cavity into two chambers. Jugum

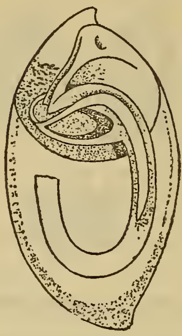


Fig. 323.—*Amphitomella hemisphœroidica*, Klipstein (sp.). (Bittner.)

situated posteriorly; saddle scarcely developed; intercalary lamellæ extending for nearly the entire length of the primary lamellæ.

Type, *Amphitomella hemisphœroidica*, Klipstein (sp.).

Distribution. Triassic.

(?) Pomatospirella, Bittner. 1892.

Shells small, unevenly convex, having the contour of Dayia and Cyclospira. Hinge-line straight, cardinal area absent

Figs. 324-326.—*Pomatospirella thecidium*, Bittner. (Bittner.)

Shell smooth, fibrous, the fibres converging toward a median line. Interior unknown.

Type, *Pomatospirella thecidium*, Bittner.

Distribution. Triassic.

(This genus is insufficiently characterized. Its known structure does not serve to distinguish it from the other genera mentioned.)

Kayseria, Davidson. 1892.

(Plate 36, figs. 1, 2.)

Shell small, with depressed-convex or lenticular valves, radially plicated exterior and a median, plicated sinus on both valves. On the interior the pedicle-valve bears a low, thickened median ridge, but is otherwise devoid of pronounced peculiarities. In the brachial valve there is a high median septum which arises from beneath the divided hinge-plate and reaches its greatest elevation at a point behind the center of the valve, whence it descends rather abruptly, traversing altogether about two-thirds the length of the valve.

The spiral cones form sharp angles with the crura, and are directed laterally; the jugum is very stout, taking its origin at about one-third the length of the primary ribbon; it is directed somewhat posteriorly, its lateral elements uniting to form a short saddle which rests upon, and is supported by the most elevated part of the median septum. Posteriorly the jugum is continued into an upright simple stem, which is continued completely across the umbonal cavity and comes into contact with the opposite valve, resting upon the median ridge of that valve or with its extremity inserted into a groove upon that ridge. The accessory lamellæ originate from a posterior elevation or process arising from the saddle of the jugum and are given off at points just in front of the crural angles. The ribbon of the principal spiral cones is comparatively broad, thickened on the inner margins, making six or seven volutions in a full-grown shell. The accessory lamellæ are also produced into spirals which though more delicate are composed of as many volutions as the principal spirals. At their outset the branches of the accessory lamellæ pass between the first and second volutions of the principal ribbon, and the two are intercoiled in this manner for their entire extent.

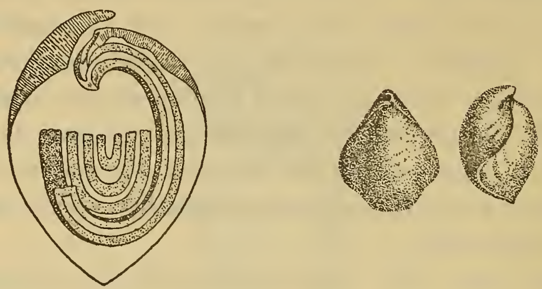
Fig. 327.—Approximate determination of the jugum in *Kayseria lens*, Phillips (sp.).

Type, *Kayseria lens*, Phillips (sp.). Middle Devonian.

But a single species is known.

Pexidella, Bittner. 1890.

Smooth, biconvex shells, with both valves greatly thickened in the umbonal regions. Spiral cones directed laterally; jugum much reduced and situated in the umbonal region; saddle scarcely



Figs. 328–330. *Pexidella Strohmayeri*, Suess (sp.). (Bittner.)

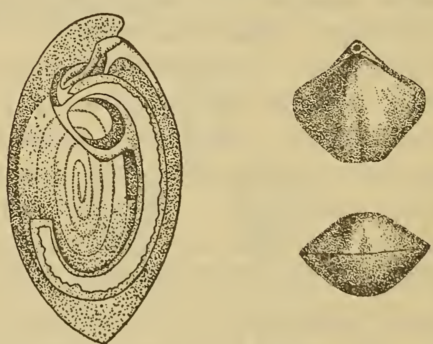
developed; intercalary lamellæ narrow and extending for nearly the entire length of the principal coils.

Type, *Pexidella Strohmayeri*, Suess (sp.).

Distribution. Triassic.

Diplospirella, Bittner. 1890.

Smooth, biconvex shells with thickened valves. Jugum well developed, situated posteriorly; saddle narrow, having the form of an oblique stem from the posterior extremity of which are



Figs. 331–333. *Diplospirella Wissmanni*, Münster (sp.). (Bittner.)

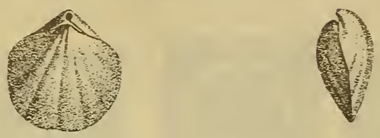
given off the intercalary lamellæ, which are broad, serrate on the outer margin and coextensive with the principal coils.

Type, *Diplospirella Wissmanni*, Münster (sp.).

Distribution. Triassic.

Euractinella, Bittner. 1890.

Shells with short corresponding ribs, obscure cardinal area and double spirals.

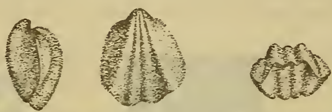


Figs. 334, 335. *Euractinella contraplecta*, Münster (sp.). (Bittner.)

Type, *Euractinella contraplecta*, Münster (sp.).
Distribution. Triassic.

Anisactinella, Bittner. 1890.

Shells with the ribs on the valves alternating in position; cardinal area, deltarium and cardinal process well developed. Spiral cones duplex, the intercalary cones giving off a process in umbonal region which returns to join the jugum, as in Merista and Meristella.



Figs. 336–338. *Anisactinella quadriplecta*, Münster (sp.). (Bittner.)

Type, *Anisactinella quadriplecta*, Münster (sp.).
Distribution. Triassic.

Retzia, King. 1850.

(Plate 36, figs. 3–7.)

Shell elongate-oval, rather broad over the pallial region. Surface covered with rather coarse, angular, usually simple plications. There is a trace of an indistinct median sinus on the pedicle-valve in which the plications are slightly smaller than those adjoining. The umbo of the pedicle-valve is incurved and its apex truncated by a circular foramen. The deltidial covering is triangular, flat or arched by the incurvature of the beak; the deltidial plates are firmly anchylosed into a single piece and the original line of symphysis is represented by a thickened ridge. The edges of the cardinal area are well defined, but not alate on either valve, the beak and area of the brachial valve being entirely concealed by incurvature. The cardinal slopes are broad and smooth. On the interior of the pedicle-valve the teeth are rather small and are supported by thin lamellæ which traverse the umbonal cavity and rest on the bottom of the shell.

Fig. 339.

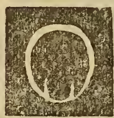


Fig. 340.

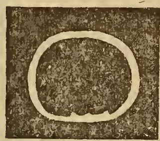


Fig. 341.

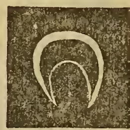


Fig. 342.

Fig. 343.

Figs. 339-343.—*Retzia Adrieni*, de Verneuil. Consecutive sections to show internal structur of the umbonal regions.

Fig. 339.—Section across opening of foramen, with umbonal tube open on the back.

Fig. 340.—Section further down, showing attachment of the remnants of the tube to the deltidial plates.

Fig. 341.—Section near the hinge, showing last traces of tube adherent to the thickened deltidial plates.

Figs. 342, 343.—Sections from another individual, one across the foramen, the other beneath it; showing the continuity of the tube.

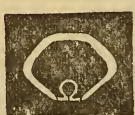


Fig. 344

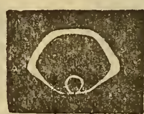


Fig. 345.

Fig. 346.

Fig. 347.

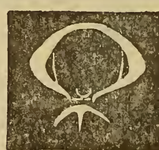


Fig. 348.

Figs. 346–358.—*Retzia Adrieni*, de Verneuil.

Fig. 344.—Section just below the foramen; showing the entire umbonal tube.

Fig. 345.—Showing the adherence of the tube to the still divided and discrete deltidial plates.

Figs. 346, 347.—Sections at the umbo of the brachial valve; showing the internal coalescence of the deltidial plates, and the open tube.

Fig. 348.—Showing the dental lamellæ, and the median septum in the brachial valve.

These lamellæ are produced forward for a short distance, limiting, posteriorly, the muscular area. The apical portion of the umbonal cavity contains a longitudinal tube attached by one side to the inner surface of the deltidial covering. Just within the outer opening of the foramen this tube appears to have been closed on all sides, but further toward the cardinal margin it becomes split along the back or outer surface, diminishing in size downward and disappearing entirely before the cardinal margin is reached. In sections made across the vertical foramen it is seen that the tube extends within the deltidial covering, and forms a subcircular enfolding of testaceous matter from the margins of the foramen.

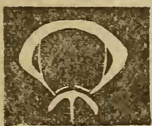


Fig. 349.

Fig. 350.

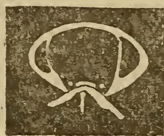


Fig. 351.

Fig. 352.

Fig. 349.—Section just above the apex of the brachial valve; showing the last traces of the deltidial plates, which are here free.

Fig. 350.—Section at the apex of the brachial valve.

Fig. 351.—Section cutting the posterior extension of the median and lateral lobes of the hinge-plate.

Fig. 352.—The same features further down; showing also the appearance of the teeth, and the remnants of the dental lamellæ bordering the muscular area of the pedicle-valve.

Fig. 353.

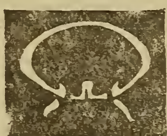


Fig. 354.

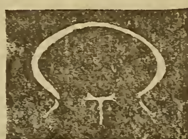


Fig. 355.

Fig. 356.

Fig. 353.—Section through the center of the hinge-plate; showing also the development of the dental sockets.

Fig. 354.—Section showing the ante-median crest of the hinge-plate.

Fig. 355.—The anterior edge of the hinge-plate and its supporting septum.

Fig. 356.—Section in front of the hinge-plate; showing the crura and median septum.

In the brachial valve the hinge-plate is subquadrate on its upper surface, its posterior margin somewhat crescentic, the horns of the crescent extending into the umbonal cavity of the opposite valve; this character, however, is not so highly developed as in Eumetria. The structure of this plate appears to be essentially similar to that of Hustedia; at all events, the tent-shaped crural supports of Eumetria are absent; there is, however, no trace here of the ligulate, curved process which occurs in

Hustedia, but the median portion of the upper face is convex and the lateral portions deeply grooved and bounded on the outside by the elevated crural bases. The hinge-plate is supported by a strong median septum which extends for nearly two-thirds the length of the valve. It is most highly elevated near the middle of its length where it extends vertically about one-fifth of the distance across the internal cavity; thence it tapers rapidly to its anterior extremity.

The brachidium has been reconstructed from serial transverse sections of the shell in several directions, and the following description may be relied upon as approximately accurate. The umbonal blades of the primary lamellæ are comparatively narrow and considerably incurved at their apices, where attached to the long crura, as in Eumetria. The jugum is situated well forward,

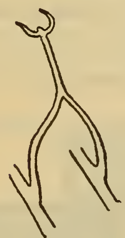


Fig. 357.

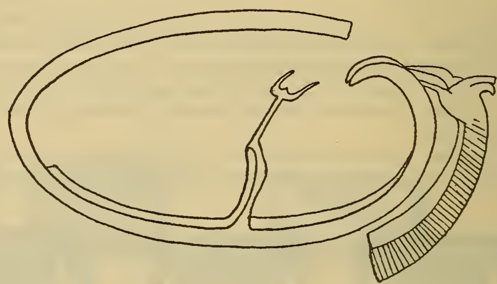


Fig. 358.

The jugum of *Retzia Adrieni*, de Verneuil, as reconstructed from consecutive sections.

just behind the center of the lamellæ; its lateral branches are erect and long; they narrow with a slight twist just above their origin, as in the genera Rhynchospira and Trematospira, then broaden, curving outward and thence inward to their point of union. The stem is short, making an angle with the lateral branches, and is directed backward. It reaches the level of the crura at a considerable distance in front of them and is there bifurcated, each arm making a slight double or sigmoid curve. These arms are, however, too short to reach the umbonal blades. The stem itself is continued for a short distance above the point of bifurcation. The spiral ribbons make ten or eleven volutions in full-grown individuals. Fimbriæ are absent from both the spirals and jugum.

Type, *Retzia Adrieni*, de Verneuil. Middle Devonian.

But one species is known.

Rhynchospira, Hall. 1859.

(Plate 36. figs. 8–12.)

Shells elongate, retziiform; hinge-line short and curved. Umbo of the pedicle-valve incurved, usually concealing the deltarium; apex truncated by a circular foramen. Cardinal slopes gradual, scarcely excavated, not forming a false area. Deltarium triangular and flat or incurved; its lateral margins are sharply defined, and its surface traversed by a longitudinal median ridge, which is the line of solid coalescence of the constituent plates. The umbonal cavity does not contain the split deltidial tube which is present in the genera Retzia, Hustedia, etc. The teeth are small and well defined, and are not supported by dental plates. Muscular impressions very obscure.

In the brachial valve the hinge-plate has the general form of that in Trematospira, but is much less elevated. Its posterior extension is slight, extending but a short distance beyond the hinge; it consists of two parts, a lower, which is closely appressed against the umbo, and deeply divided by a median cleft; and an upper, which is larger, conspicuously elevated and divided medially only at its margin, though the groove extends forward to the middle of the plate. The anterior portion is deeply concave and produced into two flat lobes which form the crural bases. The entire plate rests on stout supports which diverge at the bottom, leaving a triangular cavity beneath, in which there is a short, sometimes obscure median septum. The spirals make from six to nine volutions, the primary lamellæ being narrow and not greatly incurved. The jugum is situated behind the middle of these lamellæ and is simple in its structure; its lateral branches narrow just above their origin, with a gentle posterior inclination, then broaden and meet at a little more than one-half the distance across the base of the coils, forming a broad, short, roof-shaped process, which is directed posteriorly and terminates in an oblique edge.

Fig. 359.—The jugum of *Rhynchospira formosa*, Hall.

The external surface is radially plicate, the plications being simple. In young shells there is a median sinus on both valves, but as growth advances, that of the brachial valve develops into a low fold. Both fold and sinus bear a number of small, intercalary plications, much finer than those adjoining on each side. Shell substance rather sparsely punctate.

Type, *Rhynchospira formosa*, Hall. Lower Helderberg group.

Distribution. Devonian — Lower Carboniferous.

Subgenus Homœospira, Hall. 1893.

(Plate 36, figs. 13–19.)

Shells similar in exterior to Rhynchospira. The hinge-plate has no posterior extension, but its anterior lobes are greatly developed into long, divergent crural bases. They are separated to the apex of the beak and between them lies a small linear cardinal process. There is a stout median septum in the brachial valve whose height is equal to nearly one-half the depth of the valve. The jugum has an acute stem and its lateral branches are of the same width from their origin to the point of union. The deltidial plates frequently remain distinct and uncoalesced at maturity.

(Type, *Homœospira evax*, Hall. Niagara group.)

Ptychospira, Hall. 1893.

(Plate 36, figs. 20–23.)

Shells bearing a few sharply angular radial plications which are greatly elevated at the margins of the shell. The median plication on the brachial valve is usually divided by a fine sulcus, there being a corresponding ridge in the sinus of the opposite valve. The beak of the pedicle-valve is erect, and truncated obliquely by a circular foramen, beneath which lies a flat deltarium, the plates of which are, as in allied genera, more or less completely coalesced. The ep dermal layer of the shell is finely pitted, the punctations apparently not continuing into the layers beneath, but producing a superficial ornamentation not unlike that occurring in Eichwaldia. This ornamented layer extends even over the surface of the deltidium. The inner laminæ of the shell are fibrous and more sparsely punctated. There is no deltidial tube in the umbonal cavity of the pedicle-valve. The hinge-plate appears to be similar to that of Rhynchospira, with no prominent posterior extension, but with conspicuous crural bases which are curved upward. The whole process is supported by

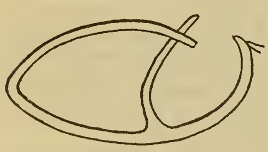


Fig. 360.—The jugum of *Ptychospira ferita*, von Buch (sp.).

a well-defined median septum. The spiral ribbon makes but few (four or five) volutions; the jugum takes its origin behind the middle of the primary lamellæ, its lateral branches being slightly constricted near their bases; it is inclined backward in a broad curve, the union of the lateral branches taking place at a point just within the opposite side of the base of the cones. From this point the stem of the jugum is continued as a simple process, outward between the coils and almost to the inner surface of the pedicle-valve.

Type, *Ptychospira ferita*, von Buch (sp.). Middle Devonian.

Distribution. Devonian — Lower Carboniferous.

Uncites, Defrance. 1827.

(Plate 36, figs. 24–27.)

Shells usually of large size, elongate-oval or subtriangular in marginal outline; valves convex. The pedicle-valve has a long and acuminate beak which is frequently distorted and always arched or incurved. There is no cardinal area and the hinge-line is greatly curved. There is no foramen in mature individuals though it may be retained in young forms. The deltarium is concave and consists of a single piece, all trace of the original components being lost. The teeth are supported by dental plates and between them lies a broad median ridge which narrows as it approaches the hinge. The brachial valve has a broad, full beak, which is closely incurved and concealed beneath the deltarium of the opposite valve. The cardinal process is large, erect and slightly bilobed on its posterior margin; it rests upon a short plate bearing two ridges which are continued into the bases of the crura. On either side of these ridges and just within the margins of the valve is a strong, oval, concave, pouch-like plate. The crura are very long, passing into the primary lamellæ without interruption. The spirals are relatively small, situated anteriorly, and consist of seven or eight volutions. These are connected by a simple erect jugum, which is situated medially,

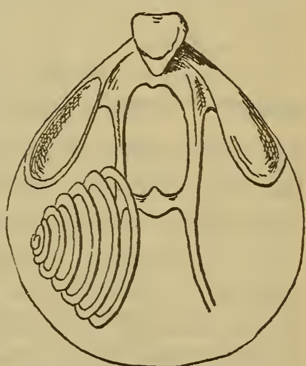


Fig. 361.—Interior of brachial valve of *Uncites gryphus*, Schlotheim; showing cardinal process, marginal pouches, spiral and jugum. (Davidson.)

and terminates at the junction of the lateral branches in a short, horizontal process.

External surface of the valves covered with numerous radiating plications; occasionally smooth. Shell-substance fibrous, impunctate.

Type, *Uncites gryphus*, Schlotheim (sp.). Stringocephalus limestone (Middle Devonian).

Uncinella, Waagen. 1883.

(Plate 37, figs. 23–25.)

Shells with a general external resemblance to Retzia. The valves are more or less finely plicated; no sinus or median fold developed; the hinge-line is curved; the beak full and strongly incurved, provided with a distant deltarium; apex truncated by a large oval foramen.

The shell bears spirals of the same general disposition as in Retzia or Uncites, but neither the jugum nor the mode of junction of the primary lamellæ with the crura is known. In the pedicle-valve below the apex of the beak, there is an excavated, small but very distinct deltarium; its composition of two pieces

Fig. 362.

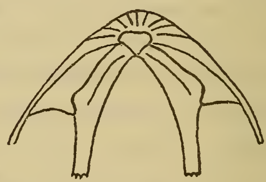


Fig. 363.

Interior cardinal region of pedicle- and brachial valves of *Uncinella indica*, Waagen. (Waagen)

has not, however, been made out. It does not reach to the hinge line, but is cut out below for the reception of the apex of the small valve. Hinge-teeth long and not supported by dental plates.

In the brachial valve the apex is flattened, and no cardinal process is present. At the apex two sharp ridges take their origin, limiting the dental sockets on the other side. These latter are elongated, deep, triangular. There is no hinge-plate, but the crura take their origin immediately at the apex, sloping strongly toward the middle line, and very nearly reaching the bottom of the valve.

Type, *Uncinella indica*, Waagen.

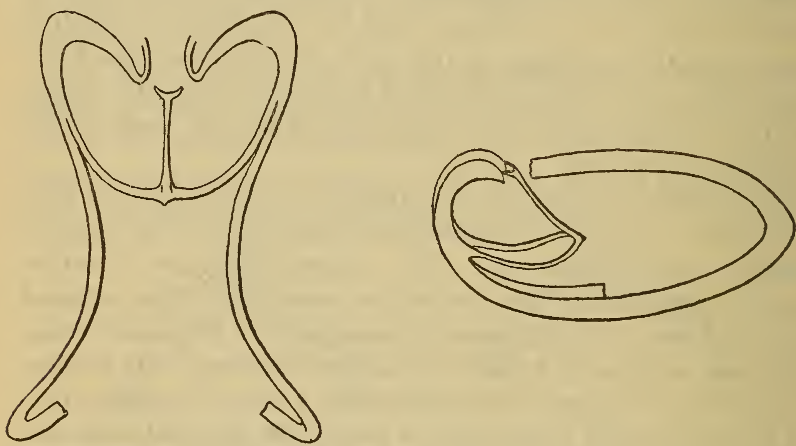
Distribution. Carboniferous.

Eumetria, Hall. 1863.

(Plate 37, figs. 1–12.)

Shells elongate-terebratuliform; outline ovate. Valves subequally convex. Hinge-line short; cardinal area of the pedicle-valve somewhat elevated, primarily composed of symmetrical deltidial plates. In the adult condition the line of symphysis between these plates is lost, or represented by a faint line, giving the deltarium the appearance of a single vertical, or slightly incurved plate, sharply defined on its lateral margins. The foramen is apical, its lower side only encroaching on the deltarium. The cardinal extremities are slightly alate, a feature more noticeable on the brachial valve and which gives this valve a somewhat pectenoid appearance. On the interior of the pedicle-valve the teeth are of moderate size, but otherwise the shell is nearly devoid of markings of any kind. There is no apical foraminal tube as in Retzia, no dental lamellæ or muscular ridges, and only in extremely rare instances is there any trace of the muscular impressions.

In the brachial valve the structure of the hinge-plate is very complicated. It may be described as composed of two parts, a posterior and an anterior. The posterior portion is rather broadly crescentic in form, having the curvature of the umbonal margin of the valve; its lateral extensions form the socket-walls, which are moderately broad, deep and well defined. On the central portion of this part of the plate rests a second crescent, having its horns, which make nearly a semi-circle, directed backward and into the umbonal cavity of the opposite valve. At this point the curvature of the plate is such that the base of the crescent lies upon the inner surface of the deltarium of the pedicle-valve, its horns crossing the deltarium, extending for fully half the length of the umbonal cavity, and being elevated, at their tips, above the inner surface of the shell. The posterior part of the hinge-plate is connected with the anterior part only by a narrow, thickened median band, which is constricted transversely at the point of union, the transverse groove being crossed only by a very fine axial ridge. The anterior portion of this plate consists of a long, narrow, triangular, concave or spoon-shaped central process, the edges of which are sharply elevated, and the extremities of these marginal ridges are produced into two long, slender and nearly vertical crura. The hinge-plate is not connected with the lateral portions of the shell, but is supported by two slightly divergent, upright lamellæ which extend to the bottom of the valve; as the valve in this region is deep, these lamellæ are very conspicuous. The crura widen as they approach the apices of the primary lamellæ, and form their union with these by a short, abrupt lateral curve. The spiral cones are approximate, their apices lateral, the ribbon making eight or nine volutions in the adult individual. The umbonal blades are broad for one-third their length, narrowing abruptly in front of the jugum. The jugum is situated posteriorly, and is constructed as follows: Two slender lateral processes are given off from the primary lamellæ, which are directed forward in low, down-



Figs. 364, 365. Two views of the jugum of *Eumetria Verneuiliana*, Hall.

ward curves, and near their extremities turn inward and upward, meeting at a point just behind the center of the shell-cavity. From their point of union a single process is extended backward at an abrupt angle and with a very gentle downward curve, terminating just in front of the apices of the primary lamellæ and above the bases of the spiral cones; its extremity is broadened and bifurcated, these secondary processes, however, extending but a very short distance. The posterior edges of the lateral branches of the jugum and of the primary lamellæ may be finely fimbriated.

There is usually no trace of a median septum in this valve, but occasionally an obscure ridge is preserved. No muscular markings have been observed.

The external surface is covered with numerous fine radiating striæ, which are rarely crossed by concentric lines. Shell-substance richly punctate.

Type, *Retzia vera*, Hall. Kaskaskia limestone.

Distribution. Lower — upper (?) Carboniferous.

(?) Acambona, White. 1862.

(Plate 37, figs. 21, 22.)

Shells similar to Eumetria. Beak of pedicle-valve prominent, incurved, pointed (?). Deltarium triangular or flat. Brachial valve without the alate cardinal extensions of Eumetria. Internal pedicle-tube slightly developed. Hinge-plate with two short processes on its posterior edge which extend for only a short distance into the umbonal cavity.

Type, *Acambona prima*, White. Burlington limestone.

Distribution. Lower Carboniferous.

Hustedia, Hall. 1893.

(Plate 37, figs. 13–20.)

Shells distinguished externally from Eumetria by their much coarser plications. The essential difference from that genus lies in the structure of the hinge-plate and the umbonal cavity of the pedicle-valve. The latter contains an internal tube attached by one side to the deltarium and split along the opposite side, a precisely similar structure to that observed in Retzia and Acambona, though not so highly developed as in the first of these. The hinge-plate is constituted as follows: It is erect and recurved into the umbonal cavity of the pedicle-valve, projecting considerably beyond the hinge-line; the upper face is convex and elevated medially, the posterior margin sinuate and crescentic, though the horns of the crescent are very short; two deep converging grooves pass over the upper face, and outside of these on the lateral margin of the plate are strong lobes which bear the erect, slightly recurved crura; from the crural bases the lateral margins curve downward to the bottom of the valve and form the socket walls. At the base of the cardinal process and in the median line arises a free, slender, ligulate process which curves upward and back-

Figs. 366-368. — Outline profile of *Hustedia Mormoni*, Marcou (sp.), with enlarged transverse sections of the umbo beneath the foramen; showing the internal tube adherent to the coalesced deltidial plates.

ward with a somewhat less curvature than the plate and rises to the highest point attained by the latter; the inner surface of this process is deeply grooved and at its base it is supported by a median septum which extends for one-third the length of the valve. There is no tent-shaped structure for the support of the crura as in Eumetria.

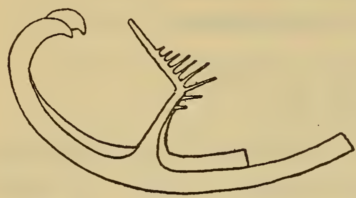


Fig. 369.—Jugum of *Hustedia Mormoni*, Marcou (sp.).

The spirals have the same structure as in Eumetria, and the posterior margins of the coils are fimbriated. The jugum, also, is quite similar to that of *Eumetria Verneuiliana*, terminating in a long, sharp, retrally directed stem, the posterior edges of the lamellæ both of the stem and the lateral branches being furnished with divergent spinules. The extremity of the stem appears to be simple.

Shell strongly punctate.

Type, *Hustedia Mormoni*, Marcou (sp.).

Distribution. Coal measures.

Trematospira, Hall. 1859.

(Plate 38, figs. 1–12.)

Shells transverse, subequally convex, with median fold and sinus on brachial and pedicle-valves respectively. Surface covered with radial, coarse or fine, simple or duplicate plications. Hinge-line straight, often long; cardinal extremities abruptly rounded; anterior margin sinuate. Umbo of the pedicle-valve incurved, its apex truncated by a circular foramen. Beneath it lies the delthyrium, which is covered by two short incurved plates, more or less closely anchylosed along the median suture, and so greatly thickened on their interior surface as to appear continuous with the substance of the valve.

The deltarium does not extend downward much more than one half the distance from the apex to the cardinal margin, leaving beneath it a crescentic opening which is occupied by the beak of the opposite valve. On either side of the deltarium is a narrow and rather abrupt flattening of the shell, suggestive of a cardinal area. The umbonal cavity is short and usually much thickened, leaving only a simple passage for the pedicle. The teeth are approximate and prominent, arising from the bottom of the valve, and above the hinge-line curved backward and toward each other, making a very close and firm articulation with the other valve. The dental lamellæ are not continued over the interior of the valve. The muscular area is well defined and consists of a deep posterior area, in front of which lies a flabelliform scar, extending for fully one-half the length of the shell.

In the brachial valve the beak is not prominent and the false area is absent. A small chilidium is present and lies against the vertical posterior wall of the hinge-plate. The hinge-plate is greatly elevated; it rests upon two stout supports which are placed very closely together, leaving no opening between them at the bottom of the valve. The upper face of the plate is quadrate, but very deeply divided by a median longitudinal groove, and less conspicuously by a transverse groove; the surface is thus divided into four parts, two posterior portions which extend backward into the umbonal cavity of the opposite valve, as short, stout horns, and two anterior processes which are broader but equally elevated; from the ante-lateral margins of the latter arise the crura. In the deep, longitudinal cleft or groove of the plate is a short, convex lobe, terminating posteriorly in a simple or double extremity; sometimes this part is absent. The whole process is rendered more prominent by being slightly constricted about its base. It is supported interiorly by a short median septum, which is frequently obsolete. The dental sockets are small and deep. The crura are broad, thin and comparatively short, and unite with the primary lamellæ in a sharp lateral curve without diminution or increase in size. The umbonal blades are not greatly incurved and are quite as narrow as any portion of the primary ribbon. The jugum takes its origin well forward near the middle of the spiral cones; the lateral branches are somewhat broadened at their origin, but become slightly constricted and twisted just above their bases, and then widen again, attaining their greatest width where they unite. From their line of union there is a short, acute and simple process extended horizontally backward. The attitude of the jugum is erect, at its base extending slightly backward and then curving broadly forward and upward; in height, it reaches rather more than half-way across the bases of the spiral cones. The cones are situated as in allied genera and the ribbon, in mature shells, makes nine or ten volutions. Muscular impressions indistinct. Shell substance punctate.

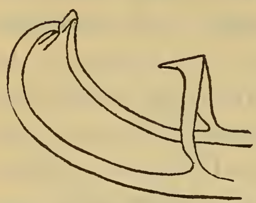


Fig. 370.— Jugum of *Trematospira multistriata*, Hall.

Type, *Trematospira multistriata*, Hall. Lower Helderberg group.

Distribution. Upper Silurian — Devonian.

Parazyga, Hall. 1893.

(Plate 38, figs. 13–20.)

Shells similar in general external aspect to Trematospira. The surface markings consist of numerous fine, rounded, simple ribs, extending alike over median fold and sinus, and these are covered with exceedingly fine, short, hair-like spines, which are usually broken off, leaving only their bases.

The umbo of the pedicle-valve is closely incurved and the deltarium (or coalesced deltidial plates) which is entirely concealed by the umbo of the opposite valve, is usually lost. The apical portion of the umbonal cavity bears an introverted lamella which forms an incomplete tube like that in Retzia, Hustedia, etc., but of no great extent. The teeth are as in Trematospira and are supported by stout plates. The muscular area is short, rather well defined, and is divided into a broad central adductor impression, along the lateral margins of which lie two flabellate diductor scars.

The hinge-plate is very narrow, and is composed of two vertical supports which have their origin on the downward umbonal slope of the shell. These supports are widely separated at their bases and enclose the marginal dental sockets; their anterior faces are vertical and their upper surfaces small and subtriangular. They do not unite with each other at any point, but each is curved slightly back of the cardinal line, and on its ante-lateral angle supports a crus. The jugum is situated at about the center of the primary lamellæ, bends backward for a short distance, and then forward at an abrupt angle. Beyond this angulation its length is about twice that before it. It terminates as in TREMATOSPIRA, in a short, sharp and simple horizontal process directed posteriorly.

FIG. 371. Jugum of *Parazyga hirsuta*, Hall.

Type, *Parazyga hirsuta*, Hall. Hamilton group.

Distribution. Devonian.

Anoplotheca, Sandberger. 1855.

(Plate 39, figs. 1–8.)

Synonym; *Bifida*, Davidson, 1882.

Shells small, oval, concavo-convex; surface with a few sparse, coarse plications, crossed by fine, often imbricating, concentric lines. Pedicle-valve with a conspicuously arched dorsum; brachial valve with a distinct median depression. On the interior of the pedicle-valve the teeth are large and stout, articulating in deep sockets on either side of a broad, thickened, slightly elevated hinge-plate. The volutions of the spirals are few and the cones are directed toward the lateral slopes of the pedicle-valve. The jugum arises at about the half-length of the primary lamellæ, the lateral branches uniting near the center of the internal cavity and forming a simple upright stem whose extremity is fitted into a longitudinally grooved callous in the pedicle-valve. In the brachial valve is a strong median septum

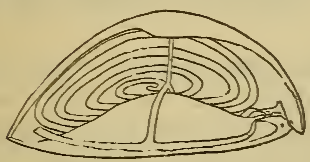


FIG. 372.

FIG. 373.

The brachidium of *Anoplotheca lepida*, Goldfuss (sp.).

FIG. 372.—A lateral view, showing the relations of the jugum to the median septum and ridge.

FIG. 373. A posterior view.

reaching for nearly the entire length of the valve and rising vertically, beneath the lateral jugal processes, almost to the jugal angle.

Shell substance fibrous, impunctate.

Type, *Anoplotheca venusta*, Schnur (sp.).

Distribution. Middle Devonian (Eifel and Torquay).

Subgenus Cœlospira, Hall. 1863.

(Plate 89, figs. 8–17.)

Shells concavo-convex, oval or circular, with coarse or fine radial, simple or compound plications. The pedicle-valve has distant teeth arising from the lateral cardinal slopes, and in front of the umbonal cavity are a pair of rather deep oval diductor scars, which embrace the anterior extremities of two narrow, less excavated adductors. These are separated by a narrow, more or less conspicuously developed median ridge.

The cardinal process has the same structure as in Anoplotheca, consisting of a central portion curved backward to, or slightly beyond the hinge and faintly bilobed on its posterior extremity. The crural bases are consolidated with the central process and are continuous with the socket walls. There is a stout median ridge dividing the muscular impressions and supporting the cardinal process.

The crura are slender and rather long, slightly converging toward their apices, forming an acute angle where they meet the primary lamellæ, the latter turning outward and backward and remaining widely separated throughout their extent. The coil is lax, the ribbon making but about three volutions, and the cones, though very slightly elevated, have their apices directed outward, toward the lateral slopes of the pedicle-valve. The shells vary considerably in convexity both naturally and from accidental compression, and where the internal cavity is shallow the spirals may appear to be coiled almost in a plane.

The umbonal curves of the primary lamellæ are very broad and stout; the jugum arises on their posterior limb, is broad and strong, its lateral processes curving gently forward and thence upward, being elevated and acutely angulated at the apex.

Beyond the junction of the lateral processes the jugum is continued as a simple stem which is inclined backward and may have been extended to the surface of the internal ridge on the pedicle-valve.

In front of the base of the jugum the primary lamellæ become at once narrow and delicate, and it not infrequently happens, in

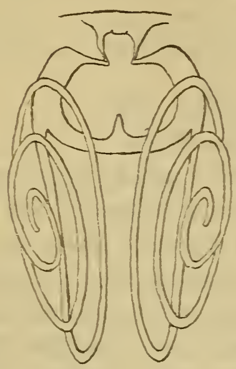


FIG 374.—The brachidium of *Cœlospira concava*, Hall.

FIG. 375.—Profile, showing the elevation of the jugum. The stem of the jugum is probably broken and, therefore, shorter than is natural.

preparations of the interior, that the more fragile portions of the ribbon are lost, leaving only the umbonal blades and the jugum.

(Type, *Cœlospira concava*, Hall. Upper Silurian (Clinton group) — Middle Devonian.)

Subgenus Leptocœlia, Hall. 1859.

(Plate 39, figs. 18–27.)

Shells similar to CŒLOSPIRA in general contour, structure of hinge, cardinal process, muscular scars and internal septa, though of larger size and coarser plication. In the original diagnosis of LEPTOCŒLIA the shell was described and figured as possessing a terebratuloid loop. It was, however, distinctly stated that the evidence of this structure was confined to a single specimen containing cavities in its filling of quartz, which corresponded to the restoration given. Subsequent investigations have not corroborated this observation.

Specimens are not often favorably preserved for the retention of the brachial apparatus, those from Cumberland, Maryland, being replaced by silica and often filled with coarsely crystallized quartz, while those from New York, Gaspé and South American localities are usually in the form of casts in an arenaceous sediment. No trace of the loop has been found, and it is highly improbable that a species agreeing in all known points of structure with the spirigerous groups just discussed and having also a fibrous shell should possess such a structure.

(Type, *Leptocœlia flabellites*, Conrad (sp.). Lower Devonian; New York, New Brunswick, Brazil, Bolivia, South Africa).

Vitulina, Hall. 1860.

(Plate 39, figs. 28–36.)

Shell of rather small size; plano-convex in contour, transverse, the hinge-line making the greatest diameter of the valves. The pedicle-valve is convex, its umbo scarcely elevated and its apex not prominent or incurved. A cardinal area is highly developed, and is divided medially by an open, triangular delthyrium, which bears no traces of deltidial plates in any condition that has been observed. The delthyrium is very wide, its base covering more than one-third the extent of the hinge-line. The teeth are blunt, thickened, and not supported by dental plates. The scar of the pedicle-muscle is distinctly defined, but those of the other muscles are obscure in their limitation. Under the most favorable preservation, there appears a posterior pair, flabellate in form, situated just in front of the pedicle-scar, and, more anteriorly, a median scar enclosed by two anterior diductor impressions. There is, at times, a low median ridge, which is purely muscular in its origin.

The brachial valve is depressed-convex or flat; it bears a narrow cardinal area coextensive with that on the opposite valve. The delthyrium is wide and open, and when the conjoined valves are viewed from behind, the cardinal process and socket-walls are clearly seen through the wide pedicle-passage. The former of these, the cardinal process, is a straight, simple apophysis, like that in Anoplotheca and Cœlospira; and the socket walls, which are also the bases of the crura, are short, but prominent and elevated, bordering deep and narrow dental sockets. The brachidium consists of loosely coiled spirals of about four volutions, the cones having their apices directed toward the lateral margins of the valves. On the dorsal side the primary lamellæ are close together, but, on the ventral side, they are wide apart, this fact indicating that the bases of the spirals do not lie in prallel planes but converge toward the brachial valve, so that the slope of the cones, which are somewhat appressed laterally, is essentially that of the lateral slopes of the pedicle-valve. The character of the jugum has not been ascertained. The muscular impressions consist of four distinct adductor scars which are separated medially by a low, thin ridge.

Surface of both valves covered by a few coarse plications, continuous from the umbones to the margins. Of these there are four or five on the lateral slopes. On the pedicle-valve the median pair is the strongest, and forms a sort of double fold with a low sinus between them. On the brachial valve there is a corresponding low median sinus, which contains a simple or double plication. The exterior is covered with fine elevated radiating lines which are usually interrupted to form radiating rows of elongate, lachrymiform pustules.

Shell substance fibrous, impunctate.

Type, *Vitulina pustulosa*, Hall.

Distribution. Lower and Middle Devonian (New York, Brazil, Bolivia, South Africa).

Anabaia, Clarke. 1893.

Shell allied to Leptocœlia in the structure of its cardinal process and articulating apparatus, having, however, a highly convex brachial valve with a median septum extending one-half its

Fig. 376. Fig. 377. Fig. 378. Fig. 379.

Figs. 376–379.—*Anabaia Paraia*, Clarke.

Fig. 376.— Exterior, showing the brachial valve.

Fig. 377.— Profile of a somewhat compressed specimen.

Fig. 378.—Interior of the brachial valve; showing the cardinal process, crura, dental sockets and septum.

Fig. 379.— Internal cast of portion of the pedicle-valve; showing the muscular scars.

length, two short, abruptly ending plications on the low median fold, upturned anterior margins, and explanate cardinal extremities.

Type, *Anabaia Paraia*, Clarke.

Distribution. Upper Silurian (Amazonas).

Nucleospira, Hall. 1859.

(Plate 38, figs. 21–38.)

Shells usually small; subcircular in outline. Valves subequally convex, often gibbous or ventricose. Hinge-line very short, cardinal extremities rounded. On the pedicle-valve the cardinal area is low and obscured by the incurvature of the beak. Only in very young specimens is the deltidium

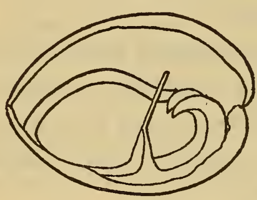


Fig. 380.

Fig. 381.

Fig. 382.

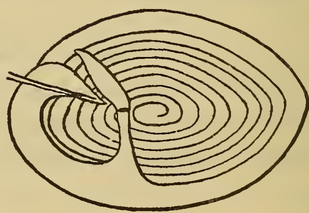


Fig. 383.

Fig. 380.—A preparation of *Nucleospira ventricosa*, Hall; showing the umbonal blades, the jugum and the form of the first volution of the spirals.

Figs. 381, 382.—The primary lamellæ and jugum of *Nucleospira ventricosa*, Hall.

Fig. 383—A preparation of *Nucleospira concinna*, Hall; showing one-half of the brachidium, the mode of attachment of the crura to the umbonal blades and the flattened stem of the jugum.

exposed, and it then consists of two plates attached to the lateral margins of the delthyrium; in mature individuals these plates are coalesced and incurved, the median suture is lost and the foramen covered; the appearance of the deltidium is that of a triangular concave plate, limited by rather sharp dental ridges and covering the delthyrium for about half its length. The teeth are prominent, approximate, recurved at the tips, supported by thickened bases but not by lamellæ. Dental sockets very narrow. The muscular area is flabellate and extends for nearly one-half the length of the shell; it is composed of two elongate-ovate adductor scars inclosed by broad and radially striated diductors. A conspicuous median septum begins in the umbonal region and extends to within a very short distance of the anterior edge of the valve.

In the brachial valve the hinge-plate arises from the bottom of the shell with a vertical anterior face; but just above the plane of the margins of the valve it is reflected in a curve so abrupt that its upper face becomes horizontal. The anterior face is concave and quadrate in outline; the posterior face is subtriangular, flat or concave, and is frequently bilobed at its extremity. In profile the plate has a hook-shaped appearance, and its posterior extremity is elevated considerably above the beak of the valve, and when the valves are in articulation, extending quite to the bottom of the umbonal cavity of the pedicle-valve. The crural bases are situated on the vertical face of the plate just at the point of recurvature. The crura are slender, straight, long and rod-like, having a length equal to fully one-fourth that of the shell. They are attached at their tips to the inner surfaces of the primary lamellæ. The primary lamellæ of the spiral coils are greatly incurved and their apices close together; their umbonal blades are very broad. The jugum originates at about one-fourth the length of the lamellæ, is inclined slightly backward, the lateral branches uniting directly in front of the apices of the lamellæ, and forming a single straight stem, which is continued beyond the opposite edge of the coil and almost to the inner surface of the pedicle-valve. The spiral ribbon makes from six to ten volutions, and the cones have their altitude in the transverse diameter of the shell.

The muscular area is very narrow and elongate, the posterior adductor scars enveloping the extremities of the anterior adductors. They are divided into pairs by a median septum of the same extent as that of the pedicle-valve. Fine racemose vascular sinuses are sometimes retained over the pallial region of both valves.

The external surface usually bears a low median sinus and fold on the pedicle-, and brachial valves respectively. The epidermal layer of the shell is usually, probably always, covered with numerous fine, short spinules; these, when removed, leave the surface with only regularly concentric growth-lines, marked by papillæ which are the bases of the spinules.

Type, *Spirifera ventricosa*, Hall. Lower Helderberg group.

Distribution. Upper Silurian — Lower Carboniferous.

Cyclospira, Hall. 1893.

(Plate 40, figs. 1–3.)

The type of this genus, *Atrypa bisulcata*, is a subtrihedral shell with a very convex pedicle-valve and a depressed brachial valve. The larger valve has a prominent umbo, the beak being closely incurved over the hinge, concealing both foramen and deltidium. The umbo is longitudinally keeled, but at about one-

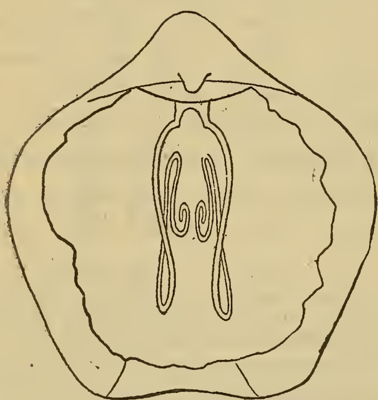


Fig. 384.

ig. 385.

The brachidium of *Cyclospira bisulcata*, Emmons (sp.).

third the length of the valve a median furrow begins on this ridge, widening anteriorly, and thus making a double keel over the forward parts of the shell. The lateral slopes are broad and smooth, interrupted only in the umbo-lateral regions by a short fold on each side, originating at the beak and lying just within the margins.

The brachial valve is slightly convex posteriorly, becoming concave medially over the pallial region. The median sinus bears a low fold corresponding to the central groove of the opposite valve. On the interior of the pedicle-valve the shell in the umbonal region is very thick, and in this thickened portion the scar of the pedicle muscle, and in front of it, the adductor scar is excavated. At the anterior edge of the muscular area the shell becomes suddenly and abruptly thinner, and thus that area lies on a well-developed, solid platform. In the brachial valve the hinge-plate is small and supported by a low median septum which extends about two-thirds the length of the valve.

The crura diverge slightly as they pass downward, making a very low curve or slight angulation at their union with the primary lamellæ. The spiral ribbon is very delicate and quite short, making but two and one-half or three volutions, which are almost circular. These spirals are coiled in planes nearly parallel to the vertical axial plane of the shell, being very slightly introverted, and the primary whorls so close together that this slight introversion brings the apices into approximation. There is as yet no satisfactory proof of the existence of a jugum; indeed, the evidence derived from a number of transparent preparations is decidedly negative upon this point. Where the crura are attached to the primary lamellæ, the ribbon is broadened, and just in front of these points there appear to have been two short convergent apophyses which may be construed as discrete elements of a jugum, but the shell appears to have been actually ajugate.

Subgenus Protozyga, Hall. 1893.

(Plate 40, figs. 4, 5.)

Shells small, subplano-convex, the pedicle-valve being the deeper. The ante-lateral margins of the valve bear evidence of broad, coarse plications.

The brachial valve has a simply divided hinge-plate, upon these divisions resting the two short convergent crura; joining the latter at a low angle, the primary lamellæ diverge laterally, converge slightly toward their anterior margins, thence curve vertically upward, nearly touching the inner surface of the pedicle-valve and very gradually approaching each other. The ribbon is continued with a decided internal inclination, until it completes slightly more than one entire volution. Toward the anterior margins of the primary lamellæ a strong jugum is given off, its lateral branches projected very obliquely backward, sometimes scarcely rising between the coils, the union forming a broad angle

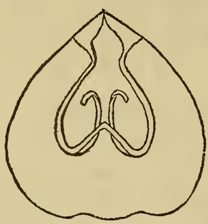


Fig. 386. Fig. 387.

The brachidium of *Protozyga exigua*, Hall.

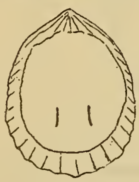
on the anterior margin with a subacute process on the outer margin.

(Type, *Protozyga exigua*, Hall. Lower Silurian (Trenton limestone).)

Hallina, N. H. Winchell and Schuchert. 1892.

(Plate 40, figs. 6–8.)

Shells small, oval in outline; valves biconvex and covered with numerous fine, sharp radial plications. Brachidium consisting of lateral processes making somewhat less than a single volution



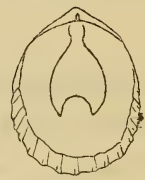


Fig. 388. Fig. 389. Fig. 390.

Preparations showing the structure of the brachidium in *Hallina Saffordi*, Winchell and Schuchert.

Fig. 388. The pedicle-valve cut so as to show the tips of the ascending lamellæ.

Fig. 389. The opposite side, showing the form of the primary lamellæ as far as the base of the jugum, and the character of the latter.

Fig. 390. View showing the brachidium in profile.

and united by a simple, posteriorly directed jugum, situated near their anterior upward curvature.

Type, *Hallina Saffordi*, N. H. Winchell and Schuchert.

Distribution. Lower Silurian (Trenton limestone.)

Glassia, Davidson. 1881.

(Plate 40, figs. 9–12.)

Shells small, biconvex; elongate-ovate in outline; surface smooth. Umbo of the pedicle-valve not conspicuous; beak depressed. Structure of the deltidium and hinge as in NUCLEOSPIRA. Muscular impression consisting of two widely divergent, oval diductor scars, between which lies a broad adductor scar.

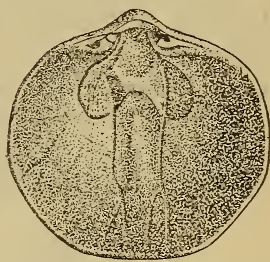


Fig. 391 *Glassia obovata*, Sowerby (sp.). Interior of the pedicle-valve.

Brachial valve with an internal septum. The spiral cones have their bases toward the lateral margins of the shell and their apices at the center of the internal cavity; their position with reference to each other is, therefore, just the reverse of that in MERISTELLA, RETZIA, etc. The cones are laterally compressed, and the ribbon makes but few volutions. The jugum originates as in ATRYPA,

FIG. 392. Brachidium of *Glassia obovata*, Sowerby (sp.). (DAVIDSON.)

is continuous, bending downward into the space between the cones and making a sharp angle at the point of union, which may be directed upward.

Type, *Glassia obovata*, Sowerby (sp.).

Distribution. Lower Silurian — Middle Devonian.

Zygospira, Hall. 1862.

Synonym, *Anazyga*, Davidson, 1882.

(Plate 40, figs. 13–25.)

Shells usually small. Outline subcircular or transversely oval. Contour subplano-convex. Surface sharply plicate. Pedicle-valve with a median plicated ridge. Umbo narrow and prominent; beak acute and incurved. Foramen elongate, rarely apical, enclosed by the deltidial plates. Hinge-line long and straight; cardinal extremities rounded. A distinct false area is formed by a pair of ridges diverging from the beak toward the

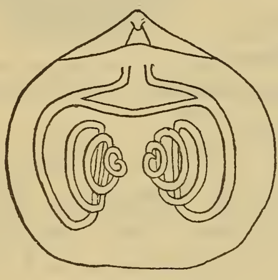


Fig. 393.

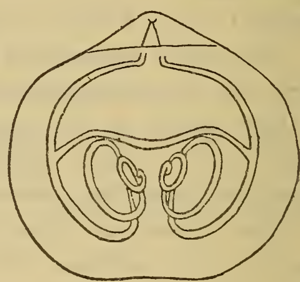


Fig. 394.

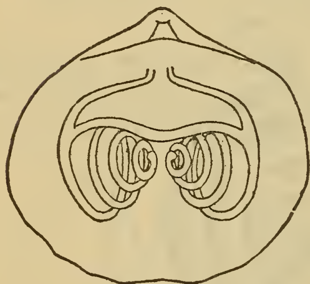


Fig. 395.

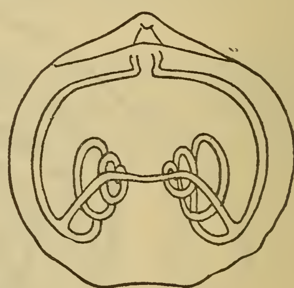


Fig. 396.

Preparations of *Zygospira modesta*, (Say) Hall; showing the variation in position of the jugum.

cardinal extremities. On the interior the teeth are moderately well developed and unsupported by dental lamellæ.

The brachial valve is depressed convex in the umbonal region and bears a more or less conspicuous median sinus. The hinge-plate consists of two broad, stout processes, diverging outwardly, grooved on their summits, and separated from each other by a narrow, sharp cleft. They form both the socket walls and crural bases, and are supported by a low median ridge. Muscular impressions obscure in the typical species.

The crura are short and straight at their union with the primary lamellæ, making a rectangular curve. The first half-volution of the ribbon lies just within the margins of the valves, and the number of volutions is small. The spirals have their bases parallel to the lateral slopes of the pedicle-valve and their apices directed obliquely toward the center of the opposite valve. The jugum is a continuous band, variable in position and shape. It may originate on the posterior or anterior limb of the primary lamellæ, or be placed medially; its apex is always angular and directed anteriorly and the lateral curves vary in length and degree according to their position with reference to the spirals.

Type, *Zygospira modesta*, (Say) Hall. Hudson River group.

Distribution. Lower — Upper Silurian.

Subgenus Catazyga, Hall. 1893.

(Plate 40. figs. 26–33.)

Shells rather large, subcircular or ovoid, with valves more convex than in Zygospira, the rotundity of the pedicle-valve obscuring the usual prominence of the umbo in that genus. Both valves bear a low median sinus, while the external surface, instead of being coarsely plicated as in Zygospira, is covered with a great number of fine radiating striæ. The typical external expression of Zygospira is thus to a large degree lost. On the interior of the pedicle-valve the muscular impressions are well defined; the pedicle-cavity is deep, and in front of it lies a more deeply excavated, short, sharply defined and longitudinally striated impression. In the brachial valve is a broad anterior and a narrow, elongate posterior pair of scars. The spirals are of essentially the same character as in *Z. modesta*, though the form of the cones is such that their apices converge toward the median line in a plane just below the surface of the brachial valve. The jugum, however, differs; it is, in the first place, persistently posterior in its position, originating as in Atrypa, the lateral lamellæ bending downward toward the bottom of the brachial-valve and directed forward in lines which are parallel for a short distance. Thence they bend inward and upward, meeting in a short angle in the space just behind the apices of the spirals.

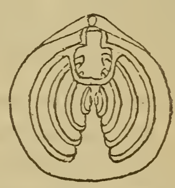


Fig. 397.—Preparation of *Catazyga Headi*, Billings (sp.); showing the form of the spiral cones and jugum as viewed from the brachial valve.

(Type, *Catazyga Headi*, Billings (sp.). Lower and Middle Silurian.)

Subgenus Orthonomæa, Hall. 1850.

(Plate 40, figs. 34–37).

Large shells, having the contour of Zygospira, but with extremely fine surface plications.

(Type, *Orthonomæa erratica*, Hall. Hudson River group.)

Clintonella, Hall. 1893.

(Plate 40, figs. 38–44.)

Shells usually small, suboval in outline; valves subequally biconvex, the axis of greatest convexity being oblique, making an angle of about fifty-five degrees with the vertical axis of the shell. Pedicle-valve with a small umbo, which is compressed laterally, the apex being slightly incurved. The cardinal area is replaced by a wide triangular delthyrium, which is unaccompanied by any trace of deltidial plates. The medially elevated umbo merges anteriorly into a sinus which makes a deep flexure at the margin; it bears two plications, both of which reach the beak; sometimes a trace of a third plication may be seen. The lateral slopes bear from four to eight radial plications of smaller size.

On the interior the teeth are prominent, strongly recurved at their tips and supported by lamellæ which terminate abruptly. The lower and inner margins of these lamellæ are thickened, contracting the pedicle cavity, which is, consequently, narrow and deep. The diductor scars are of moderate size, flabellate in outline and deeply impressed at their posterior extremity. They are crossed by traces of the radial surface plications. Between them lie the narrow obovate adductor scars.

In the brachial valve the beak is inconspicuous; the umbonal region depressed for about one-third the length of the shell, thence anteriorly becoming developed into a median fold. The greatest convexity of the valve is attained in front of the center. The cardinal margin is scarcely thickened; the dental sockets quite narrow. The hinge-plate consists of two flattened processes, inclined toward each other and closely approximate along their inner bases, though not meeting Each process is divided into an anterior and posterior lobe, the latter being the smaller and resting upon the former. These anterior lobes are narrow and slender, and constitute the crural bases. Spirals are present, but their direction and the nature of the loop are undetermined. A stout median ridge supports the hinge-plate and divides the scars of the adductor muscles. In both valves the lateral portion of the umbonal region is pitted. The plications of the surface are covered by fine, sharp and elevated concentric striæ. Shell substance, fibrous, impunctate.

Type, *Clintonella vagabunda*, Hall.

Distribution. Upper Silurian (Clinton group).

Atrypina, Hall. 1893.

(Plate 41, figs. 1–6.)

Shell small, subovate or subcircular in marginal outline, plano-, or subconcavo-convex in contour; surface coarsely and sparsely plicated.

Pedicle-valve with the umbo prominent, the beak abruptly acute and more or less incurved. Foramen apical, and deltidial plates normally developed. The cardinal margins of the valve are somewhat extended in the typical species, though the hinge itself is quite short. Teeth divergent and unsupported, taking their origin on the lateral cardinal slopes, and very slightly recurved. Muscular scars exceedingly faint; no internal septa observable.

Brachial valve with the cardinal process small, consisting of two short lobes, which meet at their apices, not extending back of the hinge-line, and diverging anteriorly. The surface of each lobe may be longitudinally grooved, but the inner and outer divisions thus formed are confluent at their outer extremities. The anterior face of the process is abrupt and vertical, its lower portion being continuous with the socket walls. In front of the cardinal process, but not supporting it, is a low median ridge, on either side of which are obscure muscular imprints. The brachial apparatus consists of introverted spirals whose bases lie against the lateral slopes of the pedicle-valve and whose apices are directed toward the center of the brachial valve. The ribbon is loosely coiled and makes

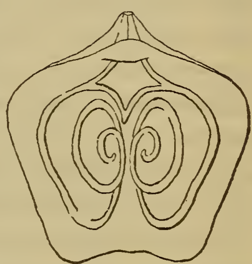


FIG. 398.—The brachidium of *Atrypina disparilis*, Hall.

but three or four volutions. The jugum is situated posteriorly and constructed as in Atrypa, except that its lateral lamellæ appear to be always united in an acute angle, which is directed inward.

Muscular impression composed of large flabellate diductors, enclosing distinct adductor scars.

Type, *Atrypina imbricata*, Hall.

Distribution. Upper Silurian —Devonian.

Atrypa, Dalman 1828.

(Plate 41, figs. 7–17.)

Shells subcircular or longitudinally suboval in outline. Gibbous, strongly inequivalve. Hinge-line short, straight; cardinal extremities rounded. Beaks not prominent.

Pedicle-valve the smaller; convex in the umbonal region, but depressed and often deeply sinuate anteriorly. Beak small, usually incurved in advanced growth-stages, concealing the foramen and deltidium. The foramen is triangular in young shells, extending to the hinge-line, but becoming gradually closed by the growth of deltidial plates, and at maturity is circular and apical, encroaching slightly on the substance of the valve. The plates of the deltidium are not coalesced along the median suture. On the interior the umbonal cavity is short but very broad. The teeth are large, widely separated and doubly grooved, first by an oblique furrow at the base, into which is fitted a crenulated ridge of the other valve, then by a short longitudinal depression on the summit; the tooth is doubly curved and reflected, making the articulation of the valves very firm. These teeth arise from the inner surface of the lateral slopes of the valve, and are hence unsupported by lamellæ. The muscular impressions are sharply defined; the triangular pedicle-scar is followed in front, by a median elongate double scar of the adductors, outside of which are strong, radiately striate, flabellate diductors, which frequently extend beyond the middle of the valve.

Brachial valve convex or rotund in the middle, with a median fold which is rarely developed except toward the anterior margin. Beak incurved and concealed. No cardinal area. The hinge-plate is composed of two diverging processes which may or may not meet at the apex. Each of these processes is obliquely grooved, forming an inner and outer lobe. The latter forms the upper portion of the socket-wall which is curved downward and unites with the lateral surface of the valve, forming a broad dental socket which is traversed by an oblique crenulated ridge. The inner lobes of the hinge-plate are short, their extremities free, bearing the crura.

These crura are long and narrow, diverge laterally and are attached to the primary lamellæ near their ante-lateral curvature. The mode of attachment is peculiar, the crural lamellæ bending upward and then abruptly downward, greatly widening at the line of contact and touching the spiral ribbon only at its outer margin. The demarkation between the crura and the ribbon of the coils is, therefore, very distinct. The spirals have, in a general sense, their bases parallel to the inner surface of the pedicle-valve and the apices directed toward the deepest point of the opposite valve. Their axes are more or less convergent, so that the approximate surfaces of the cones are flattened. The basal section of these cones is hemicordate, the anterior extremity being much the narrower, but the upper volutions are more nearly elliptical. The ribbon is broad, being conspicuously so on the anterior curves of the first few volutions, each one extending considerably beyond the next following. These anterior curves may be more or less distinctly fimbriated. The jugum is composed of two processes which are continuations of the primary lamellæ without angulation. These processes are situated posteriorly, directed toward the center of the shell, and are, in effect, the starting points of the spirals. They have the following structure: The ribbon maintains its usual width for a considerable distance within the point of attachment to the crura, then narrows rather abruptly, the processes ascending as they approach each other. Their terminations in mature shells are broadened, thickened, erect and recurved at the tips, having a clavate appearance. In immature growth-stages or undevel-

FIG. 399.—Diagram of *Atrypa reticularis*; showing the form and structure of the jugum and the mode of attachment of the crura to the hinge-plate and the primary lamellæ.

oped adult conditions this thickening is absent, the extremities of the processes are in close apposition, or may form a continuous lamella. The muscular impressions consist of four large adductor scars divided by a low median ridge.

Ovarian pittings and vascular sinuses occur over the inner surfaces of both valves. The latter consist of two main trunks, sending two branches posteriorly, and two longer converging branches anteriorly.

External surface covered with radial plications crossed by concentric growth-lines; at the crossing of the two series of lines the external layers of the shell may be produced into broad lamellar expansions or hollow spines.

Shell-substance fibrous, impunctate.

Type, *Atrypa reticularis*, Linné (sp.).

Distribution. Upper Silurian — Lower Carboniferous.

Subgenus **Gruenewaldtia**, Tschernyschew. 1885.

(Plate 41, figs. 21, 22.)

Atrypoid shells having the relative convexity of the valves in *A. reticularis* reversed. Spiral cones with their bases lying against the lateral slopes of the pedicle-valve, the outer face of the cones being thus parallel to, and just within the surface of

Fig. 400.

Fig. 401.

Spirals of *Gruenewaldtia latilinguis*, Schnur. In fig. 401, the pedicle-valve is the lower and the two median dots represent sections of the primary lamellæ. (Tschernyschew.)

the brachial valve. It is such a modification of the brachial apparatus as must necessarily ensue from the variation in the contour of the shell. The character of the jugum has not been determined.

(Type, *Gruenewaldtia latilinguis*, Schnur (sp.). Lower and Middle Devonian.)

Karpinskia, Tschernyschew. 1885.

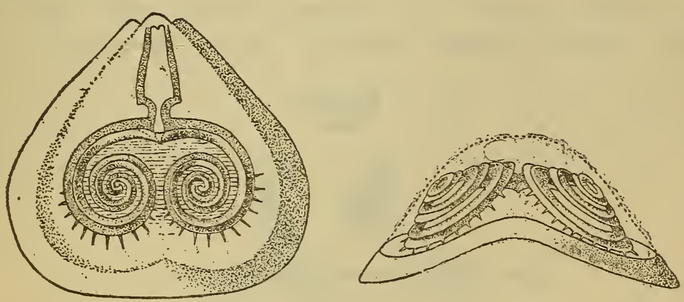
(Plate 41, figs. 18–20.)

Atrypoid shells with elongate form, radially plicated and subequally convex valves. The spirals have the same positions as in Atrypa, though the character of the jugum is still unknown. In the pedicle-valve are diverging dental plates, and in the brachial valve a median septum. The vascular trunks are simple and direct, extending to the anterior margin of the valves without branching.

Type, *Karpinskia conjugula*, Tschernyschew. Lower Devonian.

Koninckina, Suess. 1852.

Shell suborbicular, concavo-convex, smooth. Hinge-line straight. Apex of pedicle-valve incurved, beak full. Cardinal area and deltidial plates obsolete at maturity. Spirals double, the principal pair arising from simple crural processes with the extremities of which they made a sharp angle. The jugum is formed



Figs. 402, 403. *Koninckina;* reconstruction of the brachial apparatus. (Bittner.)

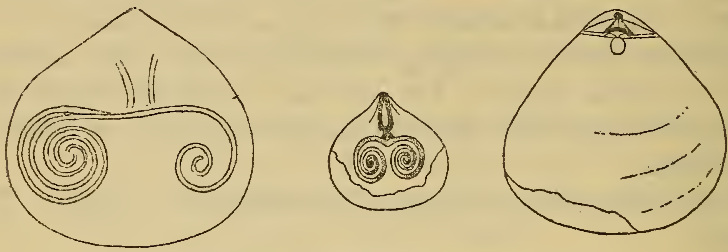
by the anterior extension and union of the crural processes. The accessory spirals are coextensive with the main pair and take their origin from the upper surface of the jugum. The spiral cones are depressed and have their apices directed toward the lateral slopes of the pedicle-valve.

Type, *Koninckina Leonhardi*, Wissman (sp.).

Distribution. Triassic.

Amphiclina, Laube. 1885.

Shell concavo-convex, subtrigonal, with straight hinge-line, well-developed cardinal and deltidial plates. Spirals duplicate, the two pairs being coextensive.



Figs. 404–406. *Amphiclina dubia*, Münster (sp.). (Fig. 405, Bittner; Figs. 404, 406, Beecher.)

Type, *Amphiclina dubia*, Münster (sp.).
Distribution. Triassic.

Koninckella, Munier-Chalmas. 1880.

Shell concavo-convex, smooth. Hinge-line straight, cardinal area, deltidial plates and cardinal process well developed. Spirals duplicate, jugum probably as in Koninckina. The

Figs. 407–409. *Koninckella triadica*, Bittner. (Bittner.)

volutions of the spiral cones are few, and the ribbon of the primary coils bear long marginal spinules.

Type, *Koninckella liasina*, Bouchard-Chantereaux (sp.).
Distribution. Lias.

Koninckodonta, Bittner. 1893.

Shell as in Koninckina but with well-developed cardinal area and deltaria. On the interior of the pedicle-valve is a submarginal row of thickened tubercles which interlock with similar callosities on the opposite valve subserving to some extent purposes of articulation. Spirals duplicate and echinate; spiral cones depressed.

Figs. 410, 411.—*Koninckodonta Fuggeri*, Bittner. (Bittner.)

Type, *Koninckodonta Fuggeri*, Bittner.
Distribution. Triassic.

Thecospira, Zugmayer. 1880.

Shells small, concavo-convex, attached by the umbo of the pedicle-valve. Surface smooth or concentrically rugose; covered with a tubercled periostracum. Shell substance perforate. Cardinal area and deltarium well-developed. In the pedicle-valve the teeth are conspicuous and unsupported; a median septum divides the deeply impressed muscular scars. In the brachial valve the cardinal process is large, elevated, tripartite on the summit, deeply grooved in the middle. Spiral cones double, directed toward the lateral slopes of the pedicle-valve. The

Figs. 412, 413.—*Thecospira Haidingeri*, Suess (sp.). (Zugmayer.)

jugum is a simple arch, broadened at its summit and continued into intercalary lamellæ which are coextensive with the principal coils. The latter are fimbriated on their outer margins.

Type, *Thecospira Haidingeri*, Suess (sp.).
Distribution. Triassic.

Amphiclinodonta, Bittner. 1890.

Shells exteriorly like Amphiclina; interiorly articulation is aided by interlocking denticulate callous ridges and tubercles lying

Fig. 414.—*Amphiclinodonta Zugmayeri*, Bittner. (Bittner).

within the margins of the valves. Structure of the brachidium as in Amphiclina.

Type, *Amphiclinodonta Zugmayeri*, Bittner.

Distribution. Triassic.

Rhynchonella, Fischer de Waldheim. 1809.

The number of palæozoic species which have been commonly referred to this genus, and, consequently, regarded as congeneric with the Russian upper Jurassic *R. loxia*, Fischer, the type-species, is very great. To the most conservative student such an agglomeration, presenting every variety of external configuration, must seem more like a hap-hazard and conventional association than a natural group. But it is, nevertheless, evident that features of internal structure, upon the variations in which generic distinctions are usually based, are here most persistent. The crura, hinge apparatus and deltidial structure of *R. loxia* are features which were attained and became fixed in the Silurian period; the extreme pyramidal contour of that species, its smooth surface with few and faint marginal plications, is not, however, except in rare instances, reproduced among the palæozoic forms. What is thus true of the predecessors of *R. loxia* is also, to a large degree at least, true of its living descendants.

From a careful study of the structure of the ancient Rhynchonellas it has become apparent that slight variations from the type of interior possessed by *R. loxia* are frequently of marked continuance, and we must, therefore, be prepared for closer discriminations in this great group of species than have elsewhere been necessary or advisable, and to emphasize such of these deviations from this stable line of development, as are justified by their persistence and the convenience of classification.

Rhynchonella, *sensu stricto.*

(Plate 42, figs. 1–3.)

Subpyramidal shells having the margins of the valves sinuous or angulated. Pedicle-valve with a median sinus beginning in front of the convex umbo and, in the type-species, becoming broad and deep, producing a prominent linguiform extension at the anterior margin. Brachial valve convex in the umbonal region and developing anteriorly a prominent median fold. Surface of both valves more or less plicated, often accompanied (as in the type) by fine concentric lines of ornament. The apex of the pedicle-valve is but slightly incurved and exposes a circular or elongate-oval foramen enclosed by the deltidial plates beneath, and above by the substance of the valves. Here is a narrow pseudo-area defined by oblique cardinal ridges diverging from the beak. On the interior the teeth are well developed and are supported by lamellæ which rest on the bottom of the valve near the beak, but are free anteriorly. The muscular area consists of a moderately deep oval scar extending one-third the length of the valve, and composed of two large diductors completely enclosing small central adductors. The posterior surface about the muscular area is pitted with ovarian markings.

In the brachial valve there is no cardinal process; the crural plates are simple, divergent, somewhat expanded on the upper surface but not conjoined except where they converge beneath the beak and meet the median septum, which extends for about one-half the length of the valve. The crura are long and curved upward toward the opposite valve. Muscular area elongate subquadrate, with small posterior and large anterior adductor scars Shell-structure fibrous.

Type, *Rhynchonella loxia*, Fischer de Waldheim.

Distribution. Jurassic. Cretaceous.

Protorhyncha, Hall. 1893.

(Plate 42, figs. 4–6.)

Shells biconvex, with a low, ill-defined fold and sinus on brachial and pedicle-valves respectively. Pedicle-valve with a false cardinal area defined by ridges diverging from the beak. Pedicle-passage triangular, rarely showing any trace of deltidial plates. Teeth very small, supported by thin lamellæ which rest upon the bottom of the valve and are not adnascent to the lateral walls of the shell. In the brachial valve the dental sockets are small; the hinge-plate consists of two minute discrete processes, the surfaces of which are slightly inclined toward each other. These were the bases of the brachial supports but show no points of attachment to the crura; they are separated by a triangular incision extending to the bottom of the valve. There is no cardinal process nor median septum in the brachial valve, and no trace of muscular scars in either valve.

Type, *Protorhyncha dubia*, Hall. Chazy limestone.

Distribution. Lower Silurian.

Orthorhynchula, Hall. 1893.

(Plate 42, figs. 7–10.)

Shells rhynchonelloid in contour; hinge-line short, straight, extending for about one-third the transverse diameter of the valves. A true cardinal area is present on both valves, that of the pedicle-valve being considerably the broader, erect, often incurved. Each valve also possesses a distinct triangular delthyrium, that of the pedicle-valve, according to the evidence at hand, never being in any degree closed by deltidial plates. External surface strongly and simply plicated, the median fold and sinus being well developed. On the interior, the pedicle-valve possesses blunt teeth which rest upon the laterally thickened walls of the valve and are not supported by lamellæ. Between, and slightly in front of these lies a short, subquadrate muscular scar. The brachial valve possesses a linear cardinal process, on either side of which are two discrete crural plates, sharply concave on the upper surface and diverging anteriorly for a considerable distance.

Shell-substance fibrous, impunctate.

Type, *Orthorhynchula Linneyi*, Nettelroth (sp.).

Distribution. Lower Silurian (Hudson River group).

Rhynchotrema, Hall. 1860.

(Plate 42, figs. 12–16.)

Shells large, thick, often gibbous. In mature conditions the deltidial plates are of great size, thickened and coalesced with the bottom of the valve, their outer surface being concave. The pedicle passage encroaches upon the substance of the valve, the foramen lying behind the apex and the passage itself inclosed by the thickened deltarium.

The teeth rest upon the thickened lateral walls of the valve, and there appears to have been no development of dental lamellæ unless it was at a very early period in the life of the individual.

In the brachial valve there is a thickened median septum which may extend for more than one-half the length of the shell; and it is upon the posterior extremity of this that the slender median cardinal process rests. This delicate apophysis is frequently distorted to one side or the other. The bases supporting the crura are divided by a very narrow median cleft, and are remarkably broad and stout, abruptly deflected to the deep dental sockets. The crura take their origin from the central portion of this comparatively broad hinge-plate, instead of from the margins of the dental sockets, as is usually the case in the palæozoic rhynchonelloids. The structure of the hinge apophyses in both valves is a persistent character, while the peculiarities of the deltarium are variable with age and external conditions. The muscular impressions are usually strongly developed, there being beneath the deltidial plates a deep scar of the pedicle muscle, while the adductor impression on the pedicle-valve is often very marked. The adductors of the brachial valve and the diductors of the pedicle-valve are more or less distinctly defined.

Type, *Rhynchotrema capax*, Conrad (sp.).

Distribution. Lower Silurian.

Rhynchotreta, Hall. 1879.

(Plate 42, figs. 17–21.)

Trihedral, strongly plicated shells with fold and sinus normal, in adolescent and mature stages; long and broad cardinal slopes; beak erect, acuminate and produced on the pedicle-valve. Foramen at maturity apical, its upper margin encroaching on the substance of the valve. Deltarium very conspicuous, convex. the component plates, in their later development, being anchylosed along the median suture. Dental lamellæ vertical, resting on the bottom of the valve and inclosing a deeply impressed muscular scar; diductor scars elongate-flabelliform, divided by oblique ridges into anterior and posterior members; adductor impression central, elongate and very small. The brachial valve bears a median septum which extends for one-half the length of the shell, is divided toward its posterior extremity, each branch supporting one process of the divided hinge-plate. The crura are long, slightly curved and somewhat expanded at their tips; between these there is a small, simple, cardinal process.

External surface covered with exceedingly fine, rounded, filiform, concentric lines. Shell-substance fibrous, impunctate.

Type, *Rhynchotreta cuneata*, Dalman (sp.).

Distribution. Lower — Upper Silurian.

Stenoschisma, Conrad. 1839.

(Plate 42, figs. 22–24.)

Subtrihedral, coarsely plicate shells; teeth supported by parallel vertical lamellæ; median septum of the brachial valve obscure or absent; median subcardinal cavity such as is found in Camarotœchia, wanting; the hinge-plate being divided by a median fissure which extends to the bottom of the shell and contains a slender longitudinal cardinal process; crura long, recurved and expanded at their extremities; surfaces of the dental sockets not crenulated.

Type, *Stenoschisma formosa*, Hall (sp.).

Distribution. Lower Helderberg.

Camarotœchia, Hall. 1892.

(Plate 43, figs. 1–9.)

Shells somewhat variable in exterior though usually maintaining a full trihedral contour with shallow pedicle-, and convex brachial valves, evincing little, if any, evidence of a reversal at maturity of the relative convexity of early growth, a feature apparent in some of the other groups of the rhynchonelloids. The median septum of the brachial valve is divided posteriorly in such a manner as to form an elongate cavity, which does not extend to the bottom of the valve. Each branch of the septum supports one of the lateral divisions of the hinge-plate, to which are attached the curved crural processes. In normal conditions of development the median interspace of the hinge-plate is not closed. The dental sockets bordering the hinge-plate are crenulated in the typical species. There is no cardinal process.

In the pedicle-valve slender vertical lamellæ support the rather small teeth and extend well into the cavity of the valve, inclosing a deep and narrow pedicle-scar.

Type, *Camarotœchia congregata*, Conrad (sp.).

Distribution. Lower Silurian — Lower Carboniferous.

Subgenus Plethorhynchus, Hall. 1893.

(Plate 43, figs. 10–15.)

Large, ponderous and ventricose shells in which the lateral parts of the hinge-plate become united, closing the triangular septal cavity but forming no cardinal process. Dental lamellæ faint, evident only in young shells; teeth large and stout, resting on the lateral walls of the valve.

(Type, *Plethorhynchus speciosus*, Hall. Oriskany sandstone.)

Subgenus Liorhynchus, Hall. 1860.

(Plate 43, figs. 16–24.)

Shells having the plications on median fold and sinus highly developed, but those on the lateral slopes usually faint or obsolete. Internal structure as in CAMAROTŒCHIA; adductor scars on the brachial valve forming a narrow, elongate-oval impression divided by the median septum.

(Type, *Liorhynchus quadricostatus*, Vanuxem (sp.). Devonian — Carboniferous.)

Wilsonia (Quenstedt), Kayser. 1871.

(Plate 44, figs. 1–5.)

Shells with subcuboidal or subpentahedral contour, fold and sinus not sharply developed except at the anterior margin, abrupt anterior slope, sharply serrated lateral margins of contact and low surface plications, each of which, on the front of both valves, is marked by a fine median line. Dental plates coalesced with the lateral walls of the pedicle-valve and the teeth upon the margins of that valve. Hinge-plate small, divided by a shallow incision. Cardinal process absent.

Type, *Wilsonia Wilsoni*, Sowerby (sp.).

Distribution. Upper Silurian — Lower Devonian.

Uncinulus, Bayle. 1878.

(Plate 44, figs. 6–9.)

Synonym; *Uncinulina*, Bayle, 1878.

Shells exteriorly like Wilsonia; interiorly with a solid, undivided hinge-plate and a highly developed cardinal process.

Type, *Uncinulus subwilsoni*, d'Orbigny (sp.).

Distribution. Devonian.

Hypothyris, (McCoy) King. 1850.

(Plate 44, figs. 10–13.)

Shells strongly subcuboidal. Teeth usually supported by short vertical lamellæ; hinge-plate quite small and composed of two broad, short lateral processes, which are divided, for a portion of their length only, by a median incision extending to the bottom of the valve but not forming an inceptive spondylium as in Camarotœchia. Dental plates large. There is but the barest indication of a median septum in the brachial valve. Muscular impressions small and not deep; those of the pedicle-valve making an oval scar continued from the narrow pedicle-cavity; those of the brachial valve being narrow, elongate and extremely obscure. Interior of the pedicle-valve frequently preserving the ovarian pittings and vascular sinuses while the characters are but faintly retained on the brachial valve.

Type, *Hypothyris cuboides*, Sowerby (sp.).

Distribution. Devonian.

Subgenus **Pugnax**, Hall. 1893.

(Plate 44, figs. 14–25.)

Shells with deep fold and sinus; elevated, and often acuminate on the anterior margin; more or less sharply plicated, the plications usually being simple, those of the fold and sinus the strongest, and those of the lateral slopes often obscure or obsolete. Pedicle-valve shallow; brachial valve deep. Teeth supported by vertical lamellæ; hinge-plate similar in structure to that of Hypothyris; the median septum of the brachial valve is extremely faint when present, but is usually undeveloped. Muscular impressions not large but well defined and clearly subdivided. Vascular sinuses sometimes retained on the pedicle-valve, always obscure on the brachial valve.

(Type, *Pugnax acuminatus*, Martin. Devonian—Carboniferous.)

Eatonia, Hall. 1857.

(Plate 44, figs. 30–40.)

Concavo-convex shells with median fold and sinus, and plicated or radiate-lineate exterior. Anterior margin deeply sinuate. From the beak of the pedicle-valve diverge two lateral cardinal ridges which limit a more or less distinct false area. On the interior the teeth are adnascent to the lateral walls of the valve, all traces of supporting lamellæ being absent. Muscular area large, flabellate and deeply excavated in the substance of the shell. Pedicle-impression broad, traversed medially by a longitudinal groove; diductors extending for about one-half the length of the shell, their outer margins being elevated; they enclose a pair of small central adductor scars whose posterior margins are raised into prominent myophores. The scars are divided by a slight median septum which is continued posteriorly; this septum being often rendered very conspicuous by the growth of the shell about the apophyses of the cardinal process of the opposite valve, and in the extreme cases its development is such that it rises above, and incloses the adductor scars, the latter being excavated in its substance.

In the brachial valve the dental sockets are long and narrow, the cardinal process very large and composed of a stout, erect stem resting upon a rather short median septum, and divided at its summit into two long, divergent, tooth-like branches, whose upper faces extend to the interior surface of the opposite valve; hence their greatest elevation is at their anterior extremities, whence they slope toward the beak of the valve, usually uniting before that point is reached. The surface of attachment of each of these apophyses is medially grooved. Below them, and at the base of the central stem, arise the crura, which are long, straight and slender, with expanded extremities. The muscular scars are clearly defined and consist of a pair of small posterior adductors, and in front of them a larger pair whose surface is radiately striated, the entire area being elongate-oval. Vascular impressions are occasionally retained in the pedicle-valve.

Type, *Eatonia medialis*, Vanuxem (sp.).

Distribution. Lower Devonian.

Cyclorhina, Hall. 1893.

(Plate 42, figs. 27–31.)

Shells of comparatively large size at maturity, subtriangular in outline; biconvex, the convexity of the brachial valve being the greater. Fold and sinus very broad, and developed in the usual manner, on brachial and pedicle-valves respectively.

On the pedicle-valve the apex is obtuse, not elevated, and is very broadly truncated by a large circular foramen, which, even in the earliest growth-stages observed, is enclosed for fully five-sixths of its periphery by the substance of the valve. The deltidial plates are incipient at maturity and scarcely evident in young shells; the delthyrial margins are extremely divergent. The cardinal line is short but straight, and its extremities are produced on each side to form a short alate process or wing, similar to those in the genus Eumetria. These extensions occur on both valves, and are very apparent in the younger shells, but become somewhat obscured with the increase of convexity accompanying maturity. On the interior, the teeth are large and blunt, and attached to the lateral walls of the shell, though they also rest upon the thick lamellæ similarly attached except at their anterior margins, and which converge downward to form a deep, broad, transversely striated pedicle-cavity. The thickened lateral margins of this impression are continued anteriorly to about the center of the shell, forming an elongate-quadrate diductor scar which incloses a small oval adductor.

The brachial valve has a convex umbo, showing no evidence of concavity in early stages of growth. Beneath the beak is a very fine, vertical, linear cardinal process which appears to be continuous with an obscure median longitudinal ridge, traversing about one-half the length of the valve. Both of these are frequently involved in the shell-substance and evident only in sections of the shell. The hinge-plate is deeply divided medially, each lateral portion being supported by a deep vertical septum resting on the bottom of the valve. The upper surfaces of the hinge processes are obliquely concave, the outer and anterior angle being much elevated and the slope thence to the dental sockets abrupt. The crura are attached to the inner margins of these plates, are not curved, but their distal extremities are expanded into spoon-shaped processes which have their concave surfaces toward the brachial valve. There are no thickened muscular scars as in the opposite valve.

The surface is covered with sharply angular, simple plications, most of which begin in the umbonal regions, and the broad fold and sinus may bear as many as from eight to twelve of these. All the plications are crossed by fine, sharp concentric lines of ornamentation, which crenulate the summits of the ridges.

Shell-substance fibrous, impunctate.

Type, *Cyclorhina nobilis*, Hall.

Distribution. Middle Devonian.

Terebratuloidea, Waagen. 1883.

Shells oval or rounded, with strongly plicated valves and a high median fold in the brachial, and a corresponding sinus in the pedicle-valve. Beak truncated with a terminal round foramen; deltidial plates distinct.

Teeth strong, not supported by dental plates. Brachial valve with a tolerably large triangular hinge-plate, which is triangularly

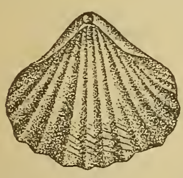


Fig. 415.

Fig. 416.

Fig. 417.

Terebratuloidea Davidsoni, Waagen.
Fig. 415.—View of the exterior.
Fig. 416.—Interior of the pedicle-valve.
Fig. 417.—Interior of the brachial valve. (Waagen.)

divided. There is no cardinal process. On both sides of the median incision very short curved crura take their origin, and proceed for a short distance in a slightly diverging direction toward the interior of the shell. There is no median septum in the brachial valve.

Type, *Terebratuloidea Davidsoni*, Waagen.

Distribution. Carboniferous — Permian.

Rhynchopora, King. 1856.

(Plate 44, figs. 26–29.)

Synonym; *Rhynchoporina*, Œhlert, 1887.

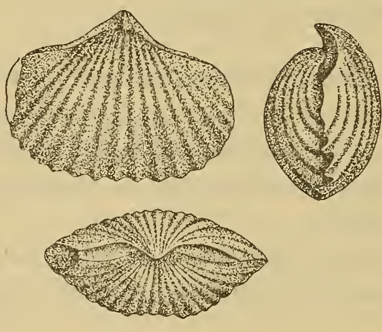
Plicate rhynchonellids with punctate shell-substance. Teeth supported by conspicuous lamellæ; hinge-plate medially divided and without cardinal process.

Type, *Rhynchopora Geinitziana*, de Verneuil (sp.).

Distribution. Carboniferous — Permian.

Halorella, Bittner. 1890.

Rhynchonellids with median depression on both valves, sharply defined false cardinal area, and depressed, subauriculate cardinal extremities.



Figs. 418–420.—*Halorella amphitoma*, Bronn (sp.). (Bittner.)

Type, *Halorella amphitoma*, Bronn (sp.).

Distribution. Triassic.

Austriella, Bittner. 1890.

Rhynchonellids of small size with smooth shells, sometimes faintly plicated about the margins.

Fig. 421–424.—*Austriella dilatata*, Suess (sp.). (Bittner.)

Type, *Austriella dilatata*, Suess (sp.).

istriubtion. Triassic.

Norella, Bittner. 1890.

Small, smooth rhynchonellids, with conspicuous median fold and sinus, and sloping hinge-line. Interior unknown.

Figs. 425, 426.—*Norella refractifrons*, Bittner. (Bittner.)

Type, *Norella sellaris*, Laube (sp.).
Distribution. Triassic.

Rhynchonellina, Gemellaro. 1871.

Shells transverse, unequally convex, the pedicle-valve being the deeper. Cardinal margin nearly straight. Beak incurved, beneath it lying a concave triangular area, bearing an incipient deltarium. Crura long, curved toward the pedicle-valve, their

Fig. 427.—*Rhynchonellina Suessi*, Gemellaro. (Gemellaro).

extremities nearly touching that valve. Near their bases these crura give off short jugal apophyses.
Type, *Rhynchonellina Suessi*, Gemellaro.
Distribution. Jurassic.

Dimerella, Zittel. 1870.

Shells small, scenidiiform, with high ventral umbo and a straight hinge-line which equals the full diameter of the valves. Surface plicate. Pedicle-passage large; deltidial plates feebly developed. Brachial valve with an elevated median septum dividing the interior shell cavity into two chambers. Crural processes long and recurved. Shell substance impunctate.

Figs. 428–433.—*Dimerella Gümbeli*, Zittel. (Bittner and Zittel)

Type, *Dimerella Gümbeli*, Zittel.
Distribution. Triassic.

Cryptopora, Jeffreys. 1869.

Synonyms; *Atretia*, Jeffreys, 1870; *Neatretia*, Œhlert, 1891.

Diminutive shells with a subtrihedral contour. Beak prominent and acute; pedicle-passage large, triangular and without deltidial plates. Interior of pedicle-valve with prominent dental

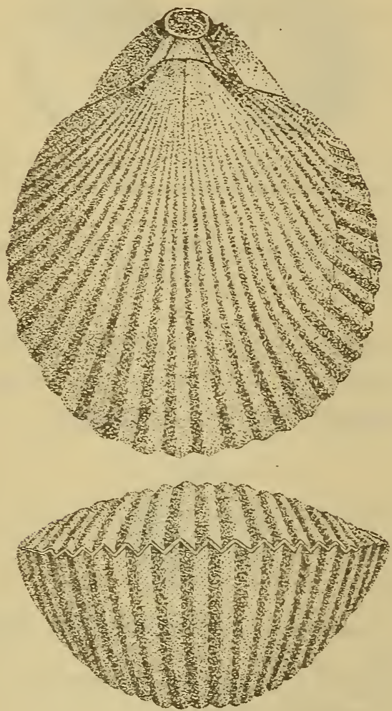
Figs. 434–437.—*Cryptopora gnomon*, Jeffreys. (Davidson).

plates; brachial valve with a short, but greatly elevated median septum.

Type, *Cryptopora gnomon*, Jeffreys.
Distribution. Recent.

Peregrinella, Œhlert. 1887.

Shells of large size, pedicle-valve the more convex. Valves without median fold and sinus. Margins even; surface plicate·



FIGS. 438, 439.—*Peregrinella multicarinata*, Lamarck (sp.). (QUENSTEDT.)

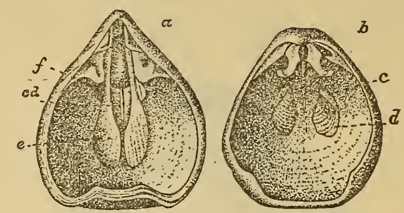
Beak short, scarcely prominent; cardinal area and deltarium well developed.

Type, *Peregrinella multicarinata*, Lamarck (sp.).

Distribution. Cretaceous.

Hemithyris, D'Orbigny. 1847.

Shells smooth or faintly plicate; median fold and sinus obscure. Beak high, with large triangular pedicle-passage and very slightly developed deltidial plates. Teeth prominent; dental plates absent. Hinge-plate divided medially, but without forming an umbonal pit. Cardinal process represented by two faint processes beneath the beak.



Figs. 440, 441.—*Hemithyris psittacea*, Gmelin (sp.) *a*, pedicle-valve; *b*, brachial valve; *c*, posterior adductors; *d*, anterior adductors; *e*, diductors; *f*, pedicle muscles. (Davidson.)

Type, *Hemithyris psittacea*, Gmelin (sp.). (Recent.)
Distribution. Tertiary (?) — Recent.

Acanthothyris, D'Orbigny. 1850.

Shells like Hemithyris, but having the surface covered with spines, and the dental plates well developed.

Fig. 442.—*Acanthothyris spinosa*, Schlotheim (sp.). (Woodward.)

Type, *Acanthothyris spinosa*, Schlotheim (sp.). (Jurassic.)
Distribution. Jurassic — Recent.

Syntrophia, Hall. 1893.

(Plate 45, figs. 1–3.)

Shells transversely elongate, biconvex, with straight hinge-line whose length nearly equals the greatest diameter of the valves; each valve medially divided by an open delthyrium External surface smooth, with fine concentric lines visible only about the margins; the inner shell-layers show a strongly fibrous radiating structure without punctation. The pedicle-valve bears a more or less clearly developed median sinus and the brachial valve a broad, indistinct fold.

On the interior the teeth are very small, lying at the extremities of the delthyrial margins and supported by dental plates which converge and unite before reaching the bottom of the valve. Thus is formed a deep but short spondylium, which is supported, near its apical portion, by a median septum, but is free for fully one-half its length.

In the brachial valve there are also two convergent plates bounding the deltidial cavity, larger and stronger than those of the opposite valve. These plates may rest upon the bottom of the valve, and, toward the posterior extremity, probably always do, but anteriorly they become free, forming a spondylium which is supported by a median septum extending beyond the anterior edge of the plate. Thus these two valves, which are very similar in exterior, the pedicle-valve being only slightly the more convex and with a low median sinus, are also closely alike on the interior, each being furnished with a spondylium.

Type, *Syntrophia lateralis*, Whitfield (sp.).

Distribution. Cambrian (?) — Lower Silurian.

Camarophoria, King. 1846.

(Plate 45, figs. 5, 6.)

Subtrigonal, concavo-convex rhynchonelliform shells, with median fold and sinus well developed, and surface more or less strongly plicated. Beak sharp, incurved; deltidial plates in an incipient condition, often wanting.

In the pedicle-valve the dental plates converge, forming a moderately large spondylium which, in the umbonal region, rests upon the bottom of the valve, but anteriorly is supported by a vertical median septum. The spondylium is short, while the supporting septum is carried beyond it, sometimes to nearly one-half the length of the shell. Near the teeth, which are small, there are two accessory supporting lamellæ abutting on one side against the outer surface of the converging dental plates, and on the other against the interior cardinal surface of the valve; thus inclosing small lateral umbonal cavities. Muscular scars of this valve always obscure.

In the brachial valve the cardinal plate is narrow, subtriangular, in the typical species bearing a very small cardinal process, which in other species is rarely present. The hinge-plate is traversed by two fine divergent ridges running outward from the beak and continuous beyond the anterior edge of the plate into long, slender and upwardly curving crura. Beneath the crura arises a broad, shallow, trough-shaped plate, which, near the apex, is supported by a short median septum resting on the valve. This process is strongly curved toward the opposite valve and is continued for most of its length beyond the termination of the median septum. Usually it widens outwardly, and then narrows rather abruptly, or even acutely, to its extremity. The adductor muscular scars are well developed in this valve, forming a broadly oval or subcircular impression.

Vascular sinuses are sometimes retained on both valves.

Type, *Camarophoria Schlotheimi*, von Buch (sp.) (Permian).

Distribution. Devonian — Permian.

Subgenus Camarophorella, Hall. 1893.

(Plate 45, figs. 5, 6.)

Valves biconvex and subcircular; without median fold, sinus and plications, the surface being smooth and regularly arched. Internal characters normal for Camarophoria, except that the broad, spatuliform spondylium rests upon the valve for most of its length, the median septum penetrating it and projecting above it into the interior cavity of the shell.

(Type, *Camarophorella lenticularis*, White and Whitfield (sp.). Burlington limestone.)

Camarella, Billings. 1859.

(Plate 45, figs. 13–19.)

Valves full, convex, smooth about the umbonal region, but anteriorly developing a few low plications which are rather the more conspicuous on the median fold and sinus, and the fold, sinus and plications are clearly developed on the usually abrupt anterior slope.

The pedicle-valve is the more convex up to maturity, but thereafter the brachial valve becomes the deeper. The beak of the pedicle-valve is erect or slightly incurved and beneath it lies a triangular delthyrium which, so far as observed, shows, neither in *C. Volborthi* nor in *C. Panderi*, any evidence of deltidial plates. The cardinal slopes are abrupt and oblique, and no cardinal area is developed on either valve. On the interior are dental lamellæ which converge, and uniting, are supported by a short median septum, forming thus a well-defined spondylium.

In the brachial valve the hinge-structure is similar to that of Camarotœchia, the crural plates converging and forming a short, very small median cavity, which is supported by a long septum. The crura are short and the lateral divisions of the hinge-plate small. No cardinal process exists.

Type, *Camarella Volborthi*, Billings.

Distribution. Cambrian (?) — Lower Silurian.

Parastrophia, Hall. 1893.

(Plate 45, figs. 20–27.)

Shells broad, tranversely oval in outline; surface with low rounded plications which are stronger on fold and sinus, apparent on the lateral slopes only near the margins of the valves. Brachial valve much the more convex, its umbo projecting conspicuously beyond that of the pedicle-valve. Cardinal margin straight and moderately long; no evidence of cardinal area in either valve.

In the pedicle-valve the delthyrium is broadly triangular and is usually filled, partially or wholly, by the beak of the opposite valve. On the interior the dental lamellæ make a strong spondylium which reaches almost to the bottom of the valve, being supported by a very low median septum extending nearly one half the length of the shell.

In the brachial valve there are two vertical crural plates not connected by a cardinal process. These are slightly convex on their inner surfaces and at their point of greatest convexity they unite with two longitudinal and gradually convergent lamellæ, which form a spondylium narrower than that of the opposite valve and supported by a very low median septum somewhat longer than that of the pedicle-valve.

Type, *Parastrophia hemiplicata*, Hall (sp.). (Trenton limestone.)

Distribution. Lower — Upper Silurian.

Anastrophia, Hall. 1867.

(Plate 45, figs. 28–35.)

Shells with strongly reversed convexity. External surface covered with numerous fine and sharp dichotomizing ribs, extending to the apices of beaks and frequently crossed by delicate concentric lines. Interior with a spondylium in each valve as in PARASTROPHIA; that of the pedicle-valve is the wider and is supported by a median septum near its anterior extremity. In the brachial valve the convergent plates generally rest upon the inner surface of the shell, though sometimes the spondylium is supported at its anterior extremity. The crural plates are extravagantly developed, forming two broad wing-shaped vertical expansions, concave on their outer surfaces; their upper edges are curved over the hinge-line, their anterior edges broadly notched, and below this point appears the base of attachment for the crura; the walls of the spondylium being connected with them at the most convex point of their inner surfaces. The dental sockets are always small, and old shells frequently show a false foramen in the beak, which is simply an extension of the spondylium that does not appear to be accidental. The muscular impressions of this valve are frequently defined as a fourfold scar about the anterior end of the spondylium; in the pedicle-valve these impressions are rarely discernible.

Type, *Anastrophia Verneuili*, Hall (Lower Helderberg)

Distribution. Upper Silurian — Lower Devonian.

Porambonites, Pander. 1830.

(Plate 45, figs. 36–38.)

Synonym; *Isorhynchus*, King, 1850.

Shells robust, transverse or elongate, sometimes distinctly triangular and globose. Valves unequally convex, the brachial valve being always the deeper. Pedicle-valve with a sinus to which there is not always a corresponding fold on the opposite valve. Hinge-line straight; hinge-teeth very strong, resting on a broad hinge-plate. In both valves is a small obtusely triangular area, which is higher in the pedicle than in the brachial valve. Both valves with a broad pedicle-passage, never closed by a deltidium. Sometimes the beak of the brachial valve is so strongly incurved that its perforation is not visible from outside. On the lateral slopes is a more or less strongly defined pseudolunule.

In the interior of the pedicle-valve are two long, robust dental lamellæ which rapidly converge and unite, sometimes before the bottom of the valve is reached, then forming a low median septum. Their anterior portion is always free while their posterior portions are sometimes coalesced into a single piece. In the brachial valve there are two short crural plates not rising to more than one-third the height of the shell; these may remain independent or sometimes unite to form a single piece.

The muscles are attached between and on the convergent plates, and, in the brachial valve, also in front of them.

Surface-sculpture variously punctate. Shell-structure apparently fibrous.

Type, *Porambonites intermedia*, Pander.

Distribution. Silurian.

Noetlingia, Hall. 1893.

Shells exteriorly like Porambonites, with long, straight hinge-line, well-developed cardinal areas and biforate beaks.

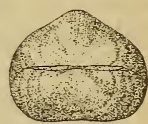


Fig. 443.—A cardinal view of a specimen of *Noetlingia Tscheffkini*, De Verneuil (sp.).

There is a spondylium in each valve, that of the pedicle-valve being, at the outset, the larger, and continuing further forward than the other. Both are supported by a stout median septal callosity, which, in the brachial valve, widens and becomes lost in the thickened shell-substance of the muscular region; that of the pedicle-valve becomes narrowed anteriorly, and eventually leaves the spondylium free,

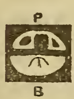


Fig. 444.

Fig. 445.

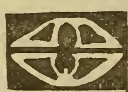
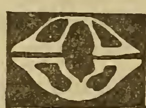


Fig. 446.



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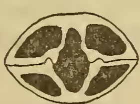

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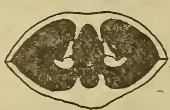


Fig. 449.

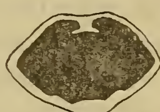


Fig. 450.

Figs. 446–452.—Transverse serial sections of a single specimen of *Noetlingia Tscheffkini*, showing the structure of the internal apophyses and septa. In all the sections the pedicle-valve (P) is above, the brachial valve (B) below.

or nearly so. There is a simple linear cardinal process in the spondylium of the brachial valve.

Type, *Noetlingia Tscheffkini*, De Verneuil (sp.).

Distribution. Lower Silurian.

Lycophoria, Lahusen. 1885.

(Plate 45, figs. 36–38.)

Valves rotund and without median fold or sinus, so that the anterior margin of contact is almost straight, or very gently sinuous. Beaks full and closely incurved, only the pedicle-valve appearing to have retained a foramen, though the cardinal area is present in both. The brachial valve bears a hinge-plate which is recurved into the pedicle-cavity of the opposite valve, and is produced into a long, curved cardinal process, bifurcate at its extremity. The crural plates are connected with the elevated margins of the four adductor impressions. In the opposite valve the teeth are supported by divergent plates which extend forward for about one-half the length of the shell and rest upon the bottom of the valve. Externally the shell is smooth in the umbonal regions, but anteriorly is covered with low, rounded plications crossed by fine concentric lines.

Type, *Lycophoria nucella*, Dalman (sp.).

Distribution. Lower Silurian.

Conchidium, Linné. 1753.

(Plate 46, figs. 1–14.)

Synonyms; *Gypidia*, Dalman, 1828; *Zdimir*, Barrande, 1881; *Antirhynchonella*, Quenstedt, 1871.

Shells elongate-subtrigonal or subpentagonal in outline, strongly inequivalve, biconvex; median fold and sinus faint, if at all developed. Anterior margins of contact usually straight, with sometimes a faint fold, at others a low sinus on both valves. Surface with numerous sharp or rounded, simple or divided plications extending from beaks to margins; cardinal slopes broad and usually smooth.

In the pedicle-valve the umbo is elevated, attenuated, more or less incurved, not prone upon the opposite valve. No cardinal area is developed. The delthyrium is very broad and bears a concave deltidium, which, however, is frequently wanting. Teeth small, supported by convergent lamellæ which unite in the interior cavity and form a single median vertical septum of variable length; in the typical species usually extending almost, and sometimes quite to the anterior margin, and vertically, for fully one-half the depth of the combined valves. The spondylium is very narrow and deep; combined with the median septum the height of these plates equals fully two-thirds the depth of the valve. The anterior margins of these plates are doubly incurved, the most projecting points being at the base of the septum, and at its line of union with the dental lamellæ. The median septum consists of two vertical lamellæ, each continuous with one of the component plates of the spondylium. The spondylium was the seat of muscular attachment, and it bears a series of fine radiating lines along its median portion, and transverse or concentric lines over its lateral slopes; the former probably representing the scar of the adductor, and the

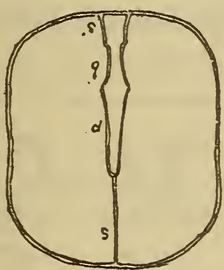


FIG. 451.

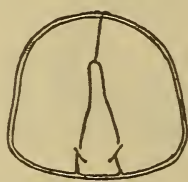


FIG. 452.

FIG. 453.—*Pentamerus (Conchidium) Knighti*. A transverse section in the umbonal region.
s. Septum of the pedicle-valve. *p*. Dental plates forming ventral spondylium.
s'. Septa of the brachial valve. *b*. Crural plates resting on the septa.

FIG. 454.—*Conchidium laqueatum*, Conrad. Transverse section, showing the deflection of the median septum, the deep, narrow spondylium of the pedicle-valve, and the septa of the brachial valve bearing inclined crural processes.

latter the impressions of the diductor muscles. In the brachial valve the beak is obtuse and closely incurved into the deltidial cavity or spondylium of the opposite valve. The dental sockets are long and narrow, their inner margins being bordered by two broad, convergent crural plates, which extend toward the bottom of the valve, but do not reach it. These sloping plates are supported by two vertical septa, with which they are united, not at their extremities, but obliquely, just within their free edges. At the anterior angles of these free edges, there are two long, straight or slightly curved, rod like crural processes extending into the anterior cavity of the shell. Beneath the beak is a faintly developed, bilobate or multilobate cardinal process. The muscular scars lie on the surface of the valve between the two vertical septa, and extend for some distance in front of them. They are divided by a low axial ridge.

Shell-substance fibrous, impunctate.

Type, *Conchidium biloculare*, Linné (=*Gypidia* or *Pentamerus conchidium*, Dalman *et al.* Upper Silurian limestone, Gotland.)

Distribution. Upper Silurian — Devonian.

Pentamerus, Sowerby. 1813.

(Plate 47, figs. 1–9.)

Smooth shells, of variable contour, sometimes bearing a few broad and obscure radiating undulations. There is no median fold and sinus, though a median prolongation of the valves, defined by two divergent lateral furrows, is a normal character. A concave deltidium is sometimes retained, and a faint lobation

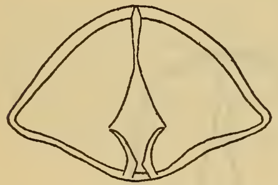


Fig. 453.

Fig. 454.

Fig. 455.

Fig. 456.

Fig. 453. *Pentamerus oblongus*, Sowerby. A transverse section, showing the septa.

Figs. 454, 455. Transverse sections of the septa of *Pentamerus oblongus*. Fig. 454 shows the septum of the pedicle-valve and the inclosure of its base by the shell-substance of the valve. Fig. 455 is an enlargement of the septa of the brachial valve, and shows a thin coating of testaceous matter upon the inner faces of the prismatic walls.

Fig. 456. *Pentamerus cylindricus*, Hall. A transverse section, showing the septa.

of the apical end of the spondylium is the sole evidence of a cardinal process. The depth of the spondylium and septal cavity varies with the convexity of the valves. Sometimes the septa unite before reaching the inner surface of the brachial valve and the spondylium thus formed is supported by a low axial septum.

Type, *Pentamerus oblongus*, Sowerby.

Distribution. Upper Silurian — Lower Devonian.

Barrandella, Hall. 1893.

Synonym; *Clorinda*, Barrande, 1879.

(Plate 48, figs. 1–5.)

Galeatiform pentameroids with median fold on the brachial valve and median sinus on the pedicle-valve. Shells small, surface smooth or rarely plicate.

The pedicle-valve bears a short spondylium supported only at its posterior surface, the free extension being produced forward and upward into the cavity of the opposite valve; the crural plates of the brachial valve are concave on their outer surfaces and supported by convergent septa uniting as they reach the valve and leaving but a single median line of union on its surface.

Fig. 457.

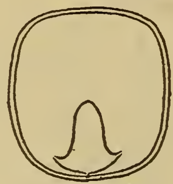


Fig. 458.

Fig. 457. *Barrandella linguifera*, Sowerby. Transverse section near the anterior extremity of the median septum in the pedicle-valve; showing the form of the spondylia.

Fig. 458. *Barrandella Barrandii*, Billings. A transverse section in front of the termination of the median septum of the pedicle-valve; showing the form of the spondylium in both valves, and the coalescence of the septa in the (lower) brachial valve.

Strong vascular, or ovarian sinuses radiate from the umbonal region of the pedicle-valve. These are complicated with the undefined diductor scars and are, therefore, to a certain extent, of muscular origin.

Type, *Barrandella linguifera*, Sowerby (sp.).

Distribution. Upper Silurian — Devonian (?).

Pentamerella, Hall. 1867.

(Plate 48, figs. 6–15.)

Shells with median fold and sinus as in Barrandella, usually larger and strongly plicate, possessing a very narrow cardinal area, an elongate pseudo-area, and incipient deltidial plates. The median septum on the interior of the pedicle-valve is very short, and at times is altogether absent. In the brachial valve the crural plates and supporting septa form a distinct spondylium which is broadly sessile on the surface of the valve.

Type, *Pentamerella arata*, Conrad (sp.).

Distribution. Devonian.

Sieberella, Œhlert. 1887.

(Plate 48, figs. 16–21.)

Galeatiform pentameroids having the median fold on the pedicle-valve and the median sinus on the brachial valve. Surface plicate without evidence of cardinal area or deltidial plates.

Pedicle-valve with well-developed median septum, and moderately long spondylium which is free for fully two-thirds its length. In the brachial valve of typical examples from the Gotland and Wenlock limestones no spondylium is formed; the septa supporting the crural plates resting directly on the surface of the valves.

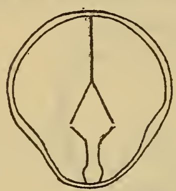


Fig. 459.

Fig. 460.

Fig. 461.—Transverse section of *Sieberella galeata*, near the beaks, the pedicle-valve being uppermost; showing the discrete septa of the brachial valve.

Fig. 462.—*Sieberella Sieberi*, von Buch. Transverse section, showing the form of the spondylia.

This is, however, a variable feature, the septa not infrequently forming a spondylium supported by a median septum.

Type, *Sieberella Sieberi*, von Buch (sp.).

Distribution. Upper Silurian — Lower Devonian.

Gypidula, Hall. 1867.

(Plate 48, figs. 22–28.)

Shells with the contour of Sieberella, plicate or smooth. Pedicle-valve with a well-defined, true, cross-striated cardinal area, and narrow, but erect or convex, incipient deltidial plates. On the interior the teeth are unusually strong, the septum very short, the spondylium being free for most of its length. In the opposite valve the dental sockets are distinct, the crural plates expanded nearly horizontally, being divided at their beginning by a narrow median cardinal process. The inner moiety of the crural plates is deflected to a vertical or slightly divergent position and in this form they are produced anteriorly. These plates rest upon two broadly convergent septa which unite with the valve making a sessile spondylium, which is acute at its anterior extremity, and lies at, or in front of the center of the

Fig. 461.—*Gypidula comis*, Owen (sp.). A transverse section in front of the short median septum of the pedicle-valve; showing the form of the spondylia.

valve. The character of this structure in the brachial valve is not variable in this genus.

Type, *Gypidula comis*, Owen (sp.).

Distribution. Devonian.

Capellinia, Hall. 1893.

(Plate 47, figs. 10–12.)

Shells large, elongate-subovate; the relative size and convexity of the valves, normal for Pentamerus, are here reversed, the brachial valve being the larger and deeper, with full, strongly arcuate and incurved umbo and beak, the apex of which is concealed within the delthyrium of the opposite valve. The pedicle-valve has an acute suberect beak which is not arched posteriorly, but rises directly from the cardinal margins. Below it is a broad delthyrium without evidence of deltidial plates; there is no hinge-line, but the margins of the delthyrium make subacute angles with the lateral margins of the valve. Cardinal slopes very broad and abrupt. The surface of the pedicle-valve is flattened above, while that of the brachial valve is evenly and deeply convex; it also shows a tendency to trilobation or obscure radical plication. The arrangement of the internal septa and spondylium is the same as in *Pentamerus oblongus*, except that the supporting septa of the brachial valve are higher and more nearly vertical.

Type, *Capellinia mira*, Hall.

Distribution. Upper Silurian.

Stricklandinia, Billings. (1863), 1859.

(Plate 49, figs. 1–7.)

Shells usually large, elongate-oval, transversely-oval or circular; in some species with a straight hinge-line, more or less extended. Valves nearly equal, varying from depressed convex to strongly convex. In the interior of the pedicle-valve is a short median septum supporting a small, triangular chamber beneath the beak. In the brachial valve are two very short or rudimentary socket plates, which in some species bear prolonged crura. Both valves with distinct cardinal area, that of the pedicle-valve the larger, the dorsal area sometimes incurved over the ventral, and concealing it wholly or in part.

Muscular impressions not clearly defined in the pedicle-valve, but in the brachial valve are two oblong or subovate scars a little below the beak, one on each side of the median line.

Type, *Stricklandinia Gaspensis*, Billings.

Distribution. Upper Silurian.

Amphigenia, Hall. 1867.

(Plate 49, figs. 8–15.)

Shells elongate-ovoid, high-shouldered, broadest behind and sloping to a narrow curve anteriorly; without median fold and sinus. Surface smooth, with irregularly distant concentric growth-rings and faint radial striæ. There is no cardinal area, and deltidial plates are not developed in the large triangular delthyrium. In the pedicle-valve is a short spondylium formed by the union of the dental lamellæ with the median septum. The muscles were implanted upon this spondylium and there is no evidence of scars elsewhere upon the valve except those left by the vascular sinuses upon the post-lateral surfaces. In the brachial valve is a large subquadrate hinge-plate, perforated by the visceral foramen which with age becomes filled up by adventitious deposits. The crura are long, straight, inclining upward or toward the opposite valve and are expanded at their extremities into palmate processes. The muscular scars in this valve are sharply developed, forming together an elongate adductor area, clearly divisible into an attenuate anterior pair and a broader posterior pair. The former have about twice the length of the latter and are marked by transverse, fine, closely-set wrinkles; the latter are radiately and coarsely striate. From the posterior termination of this area to beneath the hinge-plate extends a broad, smooth sinus, from which is given off a pair of strong lateral branches, which ramify over the genital area in the umbonal region.

The substance of the shell is impunctate on the surface. Beneath the epidermal layer is another that is highly punctated; within this, and apparently forming the innermost lamina, is a third layer whose surface is minutely wrinkled.

Type, *Amphigenia elongata*, Vanuxem (sp.).

Distribution. Lower Devonian (Corniferous limestone).

Rensselæria, Hall. 1859.

(Plate 46, figs. 1–15.)

Shells ovate or elongate-ovate in outline, subovoid in contour, broadest posteriorly; valves unequally convex, with a more or less distinct median elevation on both. Cardinal slopes broadly flattened in the typical species. Lateral margins compressed, often strongly inflected.

Pedicle-valve with full, scarcely salient umbo; beak acute, incurved, with terminal foramen. Beneath and on each side of the beak is a concave, sharply defined space, but no proper cardinal area. Distinct deltidial plates divided by a median suture may be present, but they are usually concealed by incurvature or atrophied by the encroachment of the umbo of the opposite valve. On the interior the teeth are prominent but not thickened, widely divergent and close within the margins of the valve. They are supported by stout dental plates which rest for most of their length upon the bottom of the valve, but are free along their posterior margins. These plates are closely appressed against the lateral walls of the shell and become coalescent therewith in later growth-stages. The muscular impression is restricted to the posterior portion of the valve, covering a very narrow longitudinal area. Between the dental plates at the bottom of the pedicle-cavity lies a narrow median scar, and in front of this, a very deep, elongate impression, which is sometimes clearly divided into central adductor scars embraced by the diductor impressions. Over the post-lateral slopes are numerous fine, irregularly ramifying sinuses.

The brachial valve is considerably the less convex and is often flattened. The beak is minute and usually obscured by the overlapping pedicle-valve. The hinge plate is large, flat, triangular, sometimes thin, often thickened on its posterior portion and resting on the bottom of the valve. It is separated from the lateral shell-walls by narrow dental grooves, widening at their extremities. Normally this plate is perforated by a visceral foramen entering at the under side and opening at or beneath the apex of the beak, but usually this perforation is closed by adventitious deposits. The crura are continuations of the upper portions of the supporting septa; they are broadened just beyond their base of attachment, and from their upper angles are given off the jugal processes, which are long, pointing upward and inward but not uniting. From the lower angles the descending arms take their origin, following the curves of the valve, diverging for a short distance, thence abruptly approaching, and uniting to form a broad, elongate, acutely triangular plate, which is not supported by a median septum, or otherwise connected with the valve. From the center of the posterior margin of the plate arises a small rod-like process, which extends for a short distance upward toward the crura.

The muscular area is less clearly delimited than that of the opposite valve, and its component scars are not often distinctly defined. It is, however, broader and longer than on the pedicle-valve, and is divided transversely into anterior and posterior adductor scars, the former being the larger, and their surface covered by branching lines radiating from a median longitudinal ridge. From the narrow and somewhat elevated posterior extremities of this area extends a broad median sinus, on either side of which arises a stout vascular trunk bending backward and over the post-lateral slopes. Secondary branches are given off from both its margins. These vascular markings of the genital region are rarely well defined.

Surface of the shell distinctly plicated, with sparse concentric wrinkles near the anterior margin. The radial lines may be fine or coarse, but no species is known in which the surface is entirely smooth.

Shell-substance punctated beneath the epidermal layer.

Type, *Rensselœria ovoides*, Eaton (sp.). Oriskany sandstone.

Distribution. Lower Devonian.

Subgenus Beachia, Hall. 1893.

(Plate 51, figs. 1–7.)

Shells lentiform in general contour; moderately and subequally convex; both valves with an obscure and undefined median fold. The beak of the pedicle-valve is prominent, never incurved sufficiently to conceal its deltidial plates and foramen. The cardinal margin beneath the beak is flattened into a well-defined pseudo-area, and the short inflection of the margin beginning here is continued along the lateral portion of the shell, where it meets a similar marginal inflexion from the opposite valve. These produce the sharp introversion of the lateral margins which is also one of the characteristics of the genus MEGALANTERIS.

The surface of the valves is covered with fine, hair-like radiating striæ, which are often visible only near the margins or at their thickened extremities on the inflexed portions of the shell.

On the interior the dental lamellæ are short and do not rest upon the valve. The hinge-plate is supported by two vertical septa, the median cleft and visceral foramen are more or less obscured and with sometimes a bilobed callus in its place. The brachidium has long, straight jugal processes and the triangular anterior plate in numerous specimens shows that the posterior rod-like process from the median ridge of that plate extends upward almost to the crura, but terminates abruptly and has no connection whatever with the latter.

(Type, *Beachia Suessana*, Hall. Oriskany sandstone).

Newberria, Hall. 1891.

(Plate 51, figs. 12-19.)

Shell elongate-ovoid, having the general contour and external aspect of RENSSELÆRIA and AMPHIGENIA, but without the strongly radiate-striate surface prevailing in the former genus and less strongly developed in the latter. The greatest convexity of the valves is in the umbonal region, or above the middle of their length, and in some forms the surface is distinctly flattened over the lateral slopes, leaving the median portion of the valves very prominent and sometimes subangular. The cardinal and lateral margins are regular, even and not inflected.

The pedicle-valve has the rostrum produced and incurved, the apex slightly truncated by the subcircular foramen; deltidial plates small and obscure. The teeth are comparatively small, projecting forward and gently upward, free at their extremities and supported by narrow dental plates which join the bottom of the valve above the middle of its length and are continued forward as slender, widely divergent ridges upon the inner surface, gradually merging into the shell.

In the bottom of the rostral and umbonal cavity is a broad, usually ill-defined muscular area, from which radiates a series of vascular ridges and depressions extending into the marginal region of the valve. The diductor scars are situated posteriorly and deeply impressed; between and in front of them is a narrow, elongate adductor scar which is rarely divided medially and often extends forward to, or beyond the center of the valve. On each side of the muscular impression is a thickened area, very narrow at its origin in the rostral region or pedicle-cavity and produced into divergent ridges, usually two on each side, and a fifth in the median axis. These may extend to the margins or disappear before reaching the middle of the valve and are variously subdivided by vascular grooves and sinuses emanating from them.

In the brachial valve the hinge-plate is small, similar to that of Rensselæria and Amphigenia in general form, but is of relatively less size than in the former genus and is not perforated by a visceral foramen opening beneath the apex. Two very narrow, almost linear and closely submarginal dental sockets extend nearly to the apex; within them lie two broad, subtriangular crural plates, which are divided by a triangular median fissure extending to the bottom of the valve. The inner anterior angles of these plates bear the slender crural processes, the extent of which is unknown. In mature individuals the apical portion of the hinge-plate is peculiarly constructed; the latter areas become more or less completely united, without altogether obliterating the median triangular fissure, and above this point the surface is excavated into a spoon-shaped cavity, when the development is extreme, or is transversely angular in the average individual. At a short distance from the hinge-plate and in the bottom of the valve there arises a low median ridge, which continues for a short distance, separating the obovate, narrowly flabelliform scars of the anterior and posterior adductor muscles. The anterior scars are considerably the larger, and their surface is longitudinally striated. The vascular grooves and ridges are more obscurely developed than in the pedicle-valve.

Shell-substance finely punctate.

Surface smooth or covered with fine concentric striæ, accompanied by stronger wrinkles of growth. The inner laminæ are sometimes marked by obscure radiating striæ near the margins of the valves.

Type, *Newberria Johannis*, Hall.

Distribution. Middle Devonian.

Centronella, Billings. 1859.

(Plate 52, figs. 1–7.)

Shells plano-convex or concavo-convex. Pedicle-valve with acute incurved beak, perforated at its extremity, the foramen being continuous with a partially closed delthyrium; medially ridged, and with abruptly sloping sides. On the interior the teeth are large, thick at their extremities and adherent to the lateral walls of the shell. Between them is a deep pedicle cavity, in the bottom of which lie the elongate scars of the adductor muscles, and about their anterior portion the small, flabellate diductors.

The brachial valve is very shallow, rendered concave exteriorly by a median sinus which does not make itself apparent on the interior. Beak small, apex not incurved. Dental sockets broad, bounded interiorly by the high walls of the hinge-plate. This plate is divided medially by a deep furrow extending to the apex, and, therefore, consists of two processes which are elevated, thickened and rest on the bottom of the valve. From the anterior face of these arise the crura which converge for a short distance, and expand to form two broad, acute jugal processes. From here the lateral branches of the brachidium curve outward, gradually turning from a vertical to a horizontal position, broaden rapidly and unite to form an anterior triangular plate which bears a median ridge, where the two lateral branches are conjoined. The whole of the anterior portion of the brachidium is inclined gently upward toward the cavity of the opposite valve.

Fig 462.— *Centronella glansfagea*, Hall. A preparation showing the brachidium. (Rominger.)

The muscular impressions occupy an elongate area below the hinge-plate, and are divided by a median ridge, but are only obscurely divisible into their elementary scars. The lateral portions of this valve frequently bear a series of vascular sinuses in the pallial region.

Surface smooth or with concentric lines crowded near the margins of the valves. Shell-substance punctate.

Type, *Centronella glans-fagea*, Hall. Upper Helderberg group.

Distribution. Devonian.

Subgenus **Oriskania**, Hall. 1893.

(Plate 52, figs. 11–13.)

Shells large with the characteristic naviculoid form and smooth exterior of Centr nella. The form of the brachidium has not been determined, but there is every reason to infer that it differs in no essential features from that of Centronella. The hinge-

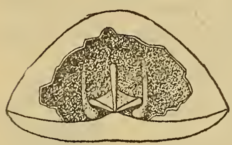


Fig. 463.

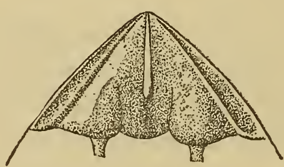


Fig. 464.

Fig. 465.

Oriskania navicella, Hall.

Fig. 463. A cardinal view; showing the hinge-plate and the elevation of the narrow median crest or cardinal process. The specimen also retains the teeth of the pedicle-valve and a portion of the dental lamellæ, though the latter are broken near the surface of the valve.

Fig. 464. An enlargement of the hinge-plate; showing the crural lobes and the extent of the cardinal process.

Fig. 465. A profile of the same specimen; showing the thickness of the plate and the uncinate form of the cardinal process. × 3.

plate is elongate-triangular, continuous between the crural bases, and bears a median vertical crest, or cardinal process, which begins at the apex, rises rapidly in height, and extends for fully one-half the length of the plate on its upper edge, but at its base is shortened and constricted, forming a projecting cardinal spur.

(Type, *Oriskania navicella*, Hall. Oriskany sandstone.)

Subgenus Selenella, Hall. 1893.

Shells with biconvex valves, smooth exterior, terebratuliform outline, narrow at the umbones and broad in the pallial region. The brachidium is similar to that of RENSSELÆRIA and CENTRONELLA; the anterior plate broader and less attenuate than in

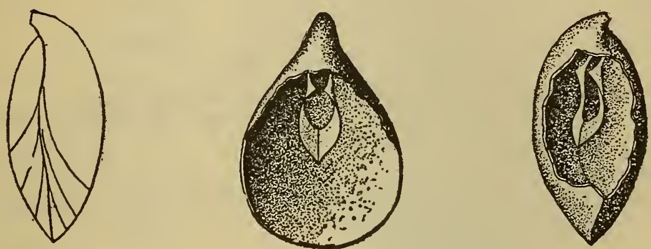


FIG. 466. FIG. 467. FIG. 468.

Selenella gracilis, Hall.

FIG. 466. Outline profile of conjoined valves.
FIG. 467. Preparation showing the form of the loop.
FIG. 468. An oblique view; showing the upward curvature of the anterior plate. × 3.

RENSSELÆRIA and without the central, rod-like posterior extension, and also lacks the median ridge or thickening along the symphysis of the lateral elements, which exists in CENTRONELLA.

(Type, *Selenella gracilis*, Hall. Upper Helderberg group.)

Subgenus Romingerina, Hall. 1893.

(Plate 52, figs. 14, 15.)

Shells, small biconvex; smooth valved. The median ridge on the anterior plate of the brachidium is elevated into a conspicuous vertical lamella, extended both anteriorly and posteriorly, being in fact a double plate produced by the abrupt deflection of each lateral branch of the brachidium near the median line; union taking place along the upper edge, which almost reaches the inner surface of the pedicle-valve.

The upper edge, where viewed from the side, is flatly roof-shaped, while the lower edge describes two convexities, the greater anterior, leaving a notch between them. The surfaces of the loop and median plate are covered with minute, obliquely conical pustules, in some cases seeming to become spinulous.

Fig. 469.

Fig. 470.

Romingerina Julia, A. Winchell.

Fig. 469. A restoration of the loop; showing the extent of the median plate.
Fig. 470. A profile view; showing the elevation of this plate, the double curvature of its upper margin and its fimbriated edge. × 4.

(A. Winchell.)

(Type, *Romingerina Julia*, A. Winchell (sp.). Upper Devonian — Lower Carboniferous.)

Trigeria, Bayle. 1875.

(Plate 52, figs. 8–10.)

Plicated centronellids with plano-convex valves. In the brachial valve the hinge-plate is tripartite, the median division

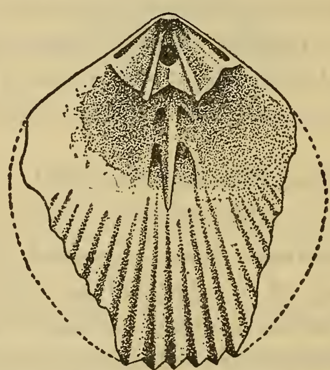


Fig. 471. *Trigeria Guerangeri*, de Verneuil (sp.).

The interior of the brachial valve; showing the perforated hinge-plate and the muscular scars. (Œhlert.)

being perforated by a visceral foramen. Brachidium as in Centronella, though with a smaller anterior plate.

Type, *Trigeria Guerangeri*, de Verneuil (sp.).

Distribution. Devonian.

Scaphiocœlia, Whitfield. 1891.

Shells of great size; plano-, or concavo-convex in contour. Pedicle-valve with a conspicuous dorsum and broad, flat lateral slopes; brachial valve with an angular median sulcus. Surface strongly plicated. Interior unknown. Shell substance fibrous impunctate (?).

Type, *Scaphiocœlia Boliviensis*, Whitfield.

Distribution. Devonian.

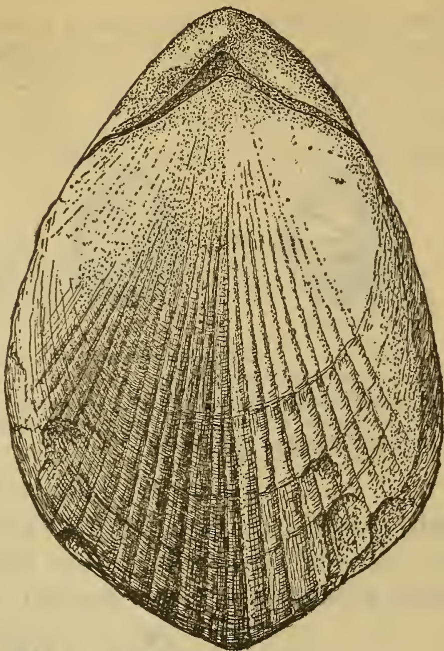


Fig. 472.

Scaphiocœlia Boliviensis, Whitfield.

Figs. 472, 473. Two views of the same individual, showing the external characters of the species. (Whitfield.)

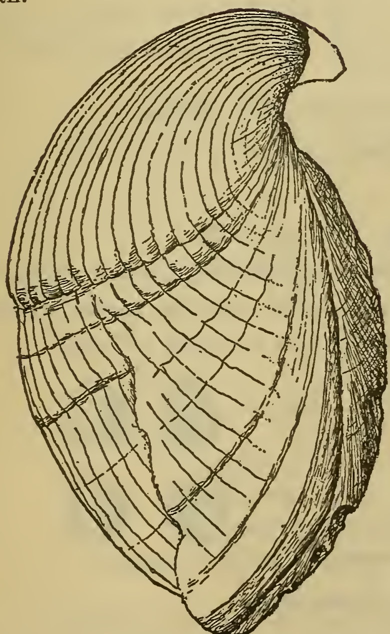


Fig. 473.

[?] Notothyris, Waagen. 1882.

Shells biconvex, coarsely plicate. Hinge-plate tripartite, perforated as in Centronella. Of the brachidium only the descending lamellæ are known.

Type, *Notothyris subvescicularis*, Davidson (sp.).
Distribution. Devonian ? — Carboniferous.

Fig. 474.

Fig. 475.

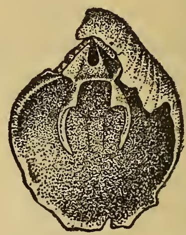


Fig. 476.

Notothyris subvescicularis, Davidson.

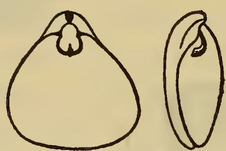
Fig. 474. A dorsal view of the exterior.

Fig. 475. A profile of the same shell.

Fig. 476. The interior of the brachial valve; showing the perforated hinge-plate and the lateral lamellæ of the loop. (Waagen.)

Juvavella, Bittner. 1890.

Shells smooth, biconvex, with a low median sinus on the pedicle-valve. Brachial valve with a very short loop, the descending branches uniting to form an expanded vertical median plate.

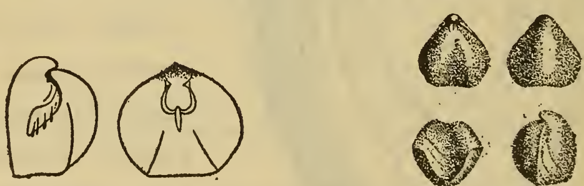


Figs. 477, 478. *Juvavella Suessi*, Bittner. (Bittner.)

Type, *Juvavella Suessi*, Bittner.
Distribution. Trias.

Nucleatula, Bittner. 1890.

Shells having the general external aspect of those of Juvavella but with a larger loop in which the vertical median plate is highly developed and fimbriated on its anterior margins.



Figs. 479–484. *Nucleatula retrocita*, Suess (sp.) (Bittner.)

Type, *Nucleatula retrocita*, Suess (sp.).
Distribution. Trias.

Dinarella, Bittner. 1892.

Small trigonal, smooth shells with deep margin at the sinus on the brachial valve. Foramen suboval, deltidial plates partially developed. Brachial valve with a median septum; brachidium

Figs. 485–490. *Dinarella Haueri*, Bittner. (Bittner.)

composed of descending lamellæ, which converge and unite to form a free vertical median plate.

Type, *Dinarella Haueri*, Bittner.

Distribution. Trias.

Megalanteris, Suess. 1855.

(Plate 51, figs. 8–11.)

Shells large, smooth, equally biconvex; suboval in outline. Shell substance punctate. Cardinal and lateral margins of the

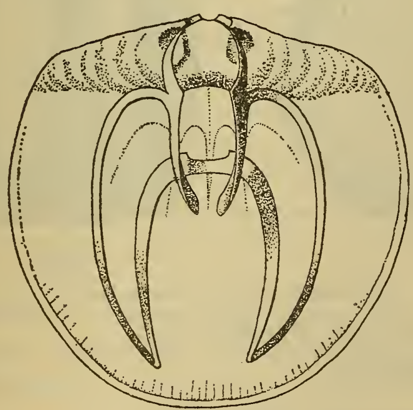


Fig. 491.

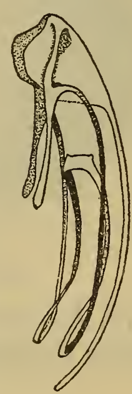


Fig. 492.

Megalanteris Archiaci, de Verneuil.

Figs. 491, 492. A restoration of the brachial apparatus.

(Suess.)

valves inflected. Apex of the pedicle-valve truncated by a foramen, beneath which lies a triangular delthyrium from which the deltidial plates have almost invariably been displaced. The muscular scars of this valve are deep and sharply defined, but restricted to the posterior portion of the shell. In the brachial valve, the hinge-plate is elevated into a stout, erect, subcylindrical cardinal process, whose posterior face is grooved and striated. Brachidium extending for nearly the entire length of the valves; jugal processes depressed, long and convergent; descending lamellæ arising at an angle from the crura; ascending lamellæ deeply reflected. Impressions of the adductor muscles long, narrow and obscure.

Type, *Megalanteris Archiaci*, de Verneuil.

Distribution. Devonian.

Enantiosphen, Whidborne. 1893.

Shells large, with smooth biconvex valves having broadly introverted margins; general external aspect as in Megalanteris. Interior with a strong ventral median septum.

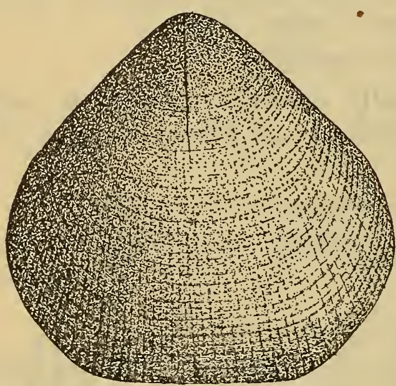


Fig. 493.

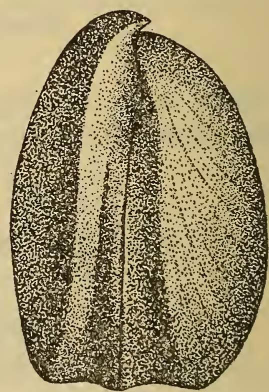


Fig. 494.

Figs. 493, 494. *Enantiosphen Vicaryi*, Davidson (sp.) (Davidson.)

Type, *Enantiosphen Vicaryi*, Davidson (sp.)

Middle Devonian (Torquay).

Cryptonella, Hall. 1861.

(Plate 52, figs. 16–23.)

Valves subequally convex; elongate-oval in outline, broadest in the pallial region. Pedicle-valve with prominent, erect or slightly incurved umbo; deltidial plates well developed; foramen circular, apical, rarely encroaching upon the umbo, or becoming oval as in many species of Dielasma; the inverted pedicle-sheath or collar is slightly developed within the aperture. The teeth are strong and supported by dental lamellæ which divide the umbonal cavity into three chambers; near the apex they join the somewhat thickened scar of the pedicle-muscle, and extend beyond its anterior margin with a slight convergence, always resting on the bottom of the valve. The pedicle-muscle makes the strongest scar of all the muscular bands, the adductors being narrow and central, and the diductors scarcely delimited.

In the brachial valve the hinge-plate is large, elongate and concave; it is divided by two low ridges diverging from the apex, and from these the plate rises toward the sides into decidedly elevated socket-walls; between the diverging ridges the surface is rather deeply depressed, and, toward the apex, is perforated by a circular foramen. The crura are slender, very short, curving inward and upward, making two long and narrow crural apophyses. The descending lamellæ are carried forward, following the curves of the valves for nearly two-thirds the length of the shell, and abruptly reflected; the ascending lamellæ returning to within a short distance of the crural apophyses. The whole structure is very similar to the brachidium of the adult living Magellania (Waldheimia).

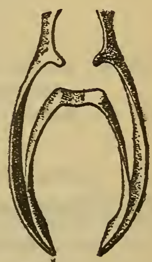


Fig 495. *Cryptonella planirostra*, Hall. The brachidium; showing the long descending and ascending lamellæ.

The adductor scars are more or less distinct, the anterior members being the more clearly defined. These scars are usually represented only by three straight lines diverging from the umbonal region. Vascular sinuses originate about the muscular areas of both valves and are directed forward with frequent ramifications.

The shell-structure is highly punctate.

Type. *Cryptonella rectirostra*, Hall.

Distribution. Devonian — Lower Carboniferous.

Subgenus Eunella, Hall. 1893.

(Plate 52, figs. 24–28.)

Shells exteriorly like Cryptonella.

The brachidium, compared with that of Cryptonella, is quite short, extending less than one-half the length of the brachial valve, and the recurvature of the ascending branches exceedingly slight. This recurved lamella is so delicate that it is rarely completely preserved, but when retained, the entire brachidium has

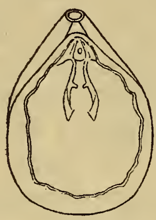


Fig. 496.

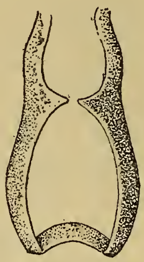


Fig. 497.

Fig. 496. *Eunella simulator*, Hall; showing the character of the hinge-plate, the relative length and usual preservation of the brachidium, with the ascending band lost.
Fig. 497. *Eunella Sullivanti*, Hall; a dorsal view of the complete brachidium.

the form represented in the adjoining figure. The crural apophyses are situated more anteriorly than in Cryptonella and are much broader at the base.

Type, *Eunella Sullivanti*, Hall (sp.). Devonian.

Harttina, Hall. 1893.

(Plate 52, figs. 29–31.)

Shells plano-convex or naviculoid; brachial valve depressed-convex or nearly flat and the pedicle-valve medially ridged with abrupt slopes at the sides. Dental lamellæ of the pedicle-valve well developed. In the brachial valve there is a short, tripartite hinge-plate, supported by a median septum of considerable height in the umbonal region and extending for fully one-half the length of the valve, becoming low anteriorly.

The crura are very short and are continued almost immediately into the long convergent crural apophyses. The descending branches of the brachidium extend for nearly the entire length of the shell, following the curvature of the valve and approaching each other anteriorly, their extremities being again directed outward. The ascending branches extend backward to points not far in front of the crural apophyses, where they are united by a transverse band. The outer margins of the descending lamellæ are fringed with rather long, irregularly set spinules directed toward the commissure of the valves. There are no spinules elsewhere on the brachidium.

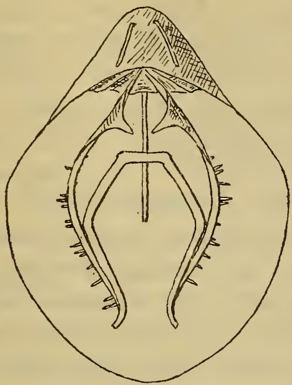


FIG. 498.

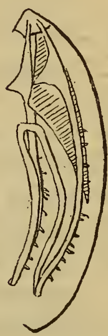


FIG. 499.

Centronella (Harttina) Anna, Hartt.

Dorsal and profile views of a preparation of the brachidium; showing the hinge-plate, broad jugal processes, fimbriated descending lamellæ, long recurved lamellæ, and prominent median septum in the brachial valve.

Type, *Harttina Anna*, Hartt (sp.).

Distribution. Carboniferous.

Dielasma, King. 1859.

(Plate 52, figs. 10–25.)

Synonym; *Epithyris*, King (not Phillips), 1850.

Shells biconvex; outline usually elongate-oval; frequently a median sinus, with or without a plication at the bottom of it, is developed in both valves.

The apex of the pedicle-valve is closely incurved, so that in adult shells but little remains of the deltidial plates. The foramen is large, quite generally encroaching upon the umbo and often becoming very oblique to the longitudinal axis; with the increase of this obliquity the deltidial plates are thickened on their inner surface, which thus becomes more or less protruded. The inverted sheath or collar within the foramen is highly developed and clearly shown on internal casts. On the interior the dental plates are conspicuous, and stand vertically upon the bottom of the valve, not showing the convergence and often actual union occurring in CRYPTONELLA.

In the brachial valve the dental sockets are quite deep and narrow, the socket-walls rising abruptly, though not attaining the height of the dental plates of the opposite valve. They are distinctly separated from the crural plates or margins of the hinge-plate, and converge toward the apex, where they merge into a slightly elevated cardinal process; the latter usually appearing as a crescentic submarginal wall, though when best preserved is seen to be composed of two lateral, somewhat rounded lobes. The crural plates are two divergent vertical lamellæ, originating just below the cardinal process, and attaining a length equal to the distance between their extremities, which is about one-third the width of the valve at that point. Between these plates lies the long, shallow hinge-plate, which is raised but little above the bottom of the valve, and is sometimes actually adherent to it. This plate attains its greatest width at the extremities of the vertical crural plates, its margins converging thence anteriorly, its full length often equaling one-third that of the valve. To this plate are attached all the muscles of the brachial valve, the scars of both anterior and posterior adductors being frequently clearly defined upon its surface. The lateral divisions of the plate have become merged with the valve and lost. The median division, which is also to a certain extent myiferous in Cryptonella, is carried to an extreme of development in Dielasma, where it forms a distinct platform. The crura are greatly abbreviated. The descending lamellæ of the brachidium are attached to, and are continuous with the crural plates, as far as the latter extend. The crural apophyses on the upper margins of these lamellæ are developed behind the points where the lower margins of the lamellæ are free from the crural plates. The lateral parts of the brachidium are more or less divergent, the recurvature of the ascending lamellæ rather short and the

Fig. 500. *Dielasma bovidens*, Morton. An enlargement of the umbonal portion of the brachial valve, showing the slightly thickened processes on either side of the beak.

Fig. 501. *Dielasma elongatum*, Schlotheim. The interior of the umbonal region of the two valves, showing the highly developed dental plates (*d*), the elongate, sessile hinge-plate with its muscular scars, and the form and mode of attachment of the brachidium. (Davidson.)

entire structure does not extend beyond the middle of the shell. The ascending lamellæ are very fragile and usually destroyed in fossilization.

Type, *Dielasma elongatum*, Schlotheim (sp.).

Distribution. Devonian (?) — Permian.

Subgenus Cranæna, Hall. 1893.

(Plate 53, figs. 4–9.)

Biconvex shells having the hinge-plate constructed as in Cryptonella and not adherent to the bottom of the valve as in Dielasma; the crura also arise normally from the lateral divisions of this plate. Form of the brachidium as in Dielasma, its descending branches being highly divergent, the ascending branches abruptly recurved, making a broad, gentle curvature above; at the same time this recurved band is so very fragile as to be almost invariably destroyed. The entire length of the loop, as in Dielasma, and in contradistinction to Cryptonella and Eunella, is about one-third that of the brachial valve.

Fig. 502. *Cranæna Romingeri*, Hall, (sp.). An outline showing the Dielasma-form of the brachidium and the divided hinge-plate.

(Type, *Cranæna Romingeri*, Hall (sp.). Devonian.)

Dielasmina, Waagen. 1882.

Plicated shells which possess more or less of the characters of Dielasma. They have the dental plates of the pedicle-valve and

Fig. 503. Fig. 504.
Dielasmina plicata, Waagen.
Dorsal and front views. (Waagen.)

the general form of the brachidium in that genus, as far as the interior is now known.

Type, *Dielasmina plicata*, Waagen.

Distribution. Carboniferous.

Hemiptychina, Waagen. 1882.

Plicated biconvex shells without dental plates, but with the hinge-structure and brachidium of Dielasma.

Fig. 505. *Hemiptychina Himalayensis*, Davidson.

A portion of the interior; showing the absence of dental plates in the pedicle-valve, and the Dielasma-like brachidium. (Waagen.)

Type, *Hemiptychina Himalayensis*, Davidson (sp.).
Distribution. Carboniferous — Permian.

Beecheria, Hall. 1893.

(Plate 53, figs. 1–3.)

Non-plicated shells in which the dental plates are absent or represented only by faint ridges which do not reach the bottom of the pedicle-valve.

The peculiar myiferous hinge-plate of Dielasma is wholly merged with the valve, but the crural ridges are stlll retained and the descending lamellæ originate from them at the bottom of the

Fig. 506. *Beecheria sublœvis*, Waagen (sp.)
Dorsal view: showing the smooth exterior. (Waagen.)
Fig 507. *Beecheria Davidsoni*, Hall.
An enlarged profile of the brachidium; showing the manner in which lamellæ arise from the bottom of the valve, the broad posterior jugal processes and the much narrower descending lamellæ. The anterior transverse or reflected band is not fully retained.

valve in very much the same way as in Dielasma. The crural apophyses are broad and erect, there being no part of the descending branches behind them. Sometimes the brachial valve retains a low muscular impression which has the form of the platform of Dielasma.

Type, *Beecheria Davidsoni*, Hall.
Distribution. Carboniferous.

(?) Cryptacanthia, White and St. John. 1867.

Shells small plano-convex or naviculoid. Loop long and recurved; jugal processes united above. (?) Outer margins of the brachidium covered with spines.

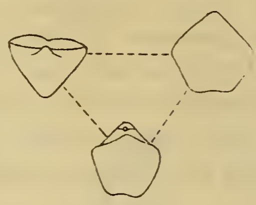


Fig. 508.

Cryptacanthia compacta, White and St. John.
A copy of the original figure.
(White and St. John.)

Type, *Cryptacanthia compacta*, White and St. John.
Distribution. Carboniferous.

Stringocephalus, Defrance. 1827.
(*emend.* Sandberger. 1842.)

Shells varying in outline from transverse to elongate-oval; biconvex, the brachial valve being somewhat the deeper; the greater convexity is in the umbonal region, giving to the brachial valve a high-shouldered appearance.

On the pedicle-valve the beak is somewhat narrow, its apex being abruptly attenuate, acute and often greatly incurved. From beneath the beak diverge two sharp ridges extending to the extremities of the hinge, and delimiting the broad cardinal excavations which seem to constitute a true cardinal area. The delthyrium is broad and triangular; in young shells it may be wholly open or incompletely closed by the imperfectly developed deltidial plates, while at maturity it is closed, with the exception of a circular foramen, and in old shells the deltidial plates are anchylosed, forming a single plate which becomes incurved, and the foraminal passage is thus obscured, and may take the form of a tube or sheath prolonged into the umbonal cavity.

On the interior the teeth are short, free and curved upward at their extremities. In the middle of the valve is a vertical longitudinal septum, which extends from the beak to near the anterior margin. This septum is short and thick posteriorly, but becomes thinner and higher towards the front, ending abruptly in the pallial region.

In the brachial valve the umbo is obtuse. The cardinal area is distinctly developed and divided by a very broad triangular fissure, the covering of which (chilidium) is frequently retained, much modified by the presence of the great cardinal process. The dental sockets are comparatively shallow. The general form of the hinge-plate is triangular, with its apex anterior; its central portion is separated from the narrow, blade-shaped lateral divisions and is produced into a great cardinal process, rounded

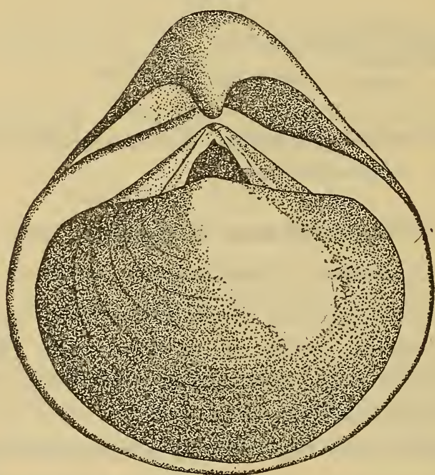


Fig. 509. *Stringocephalus Burtini*, Defrance.

Dorsal views of two individuals; showing the differences assumed in growth by the umbo of the pedicle-valve. (Quenstedt.)

posteriorly, narrow and sharp on its anterior surface, and produced upward and backward into the cavity of the opposite valve. At the edge of the median septum of that valve it bifurcates, sending out a short clavate apophysis on either side of it. The lateral portions of the hinge-plate begin at the socket-walls which are high and narrow, extend downward, inward and forward to the anterior extremity of the plate, whence they curve upward into the crura. The crura are long, broadened and curved upward towards their extremities where the primary arms of the brachidium arise at a sharp angle. The latter curve backward and outward, and skirt the inner margins of the valves as a very broad, continuous lamella, which is not reflexed though somewhat curved upward on the anterior margin. From the inner margins of this lamella, on its exterior and lateral

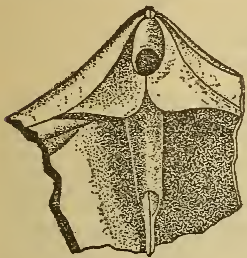


Fig 510.

Fig. 511.

Fig. 512.

Stringocephalus Burtini, Defrance.

Fig. 510. Umbonal cavity of the pedicle-valve with discrete deltidial plates.

Fig 511. The internal sheath or projection of the pedicle-passage.

Fig 512. The umbonal cavity of a pedicle-valve in which coalescence of the deltidial plates is almost complete. (Quenstedt.)

extension, arises a series of linear processes converging toward, and some of them perhaps reaching the crura. A low, thick median septum extends for about half the length of the valve.

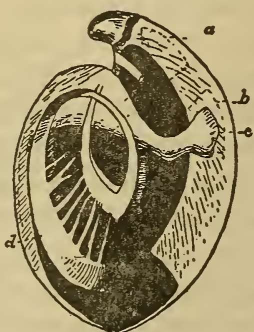


Fig. 513. *Stringocephalus Burtini*, Defrance.

A restoration of the interior, showing the internal pedicle-sheath and the strong median septum of the pedicle-valve; the great cardinal process, one of its terminal lobes (*c*) lying on either side of the septum; the form of the loop with the radial filaments extending from the anterior lamellae (*d*) to the crura. At (*a*) is the insertion of the diductor muscle, (*b*) that of the adductor. (Hoernes.)

The muscular impressions on both valves are exceedingly obscure, and have never been fully described or illustrated.

Surface smooth, with fine concentric growth-lines ; sometimes a low median sinus exists on both valves near the margin.

Shell-substance impunctate externally, but the inner laminæ are sparsely perforated.

Type, *Stringocephalus Burtini*, Defrance. Middle Devonian.

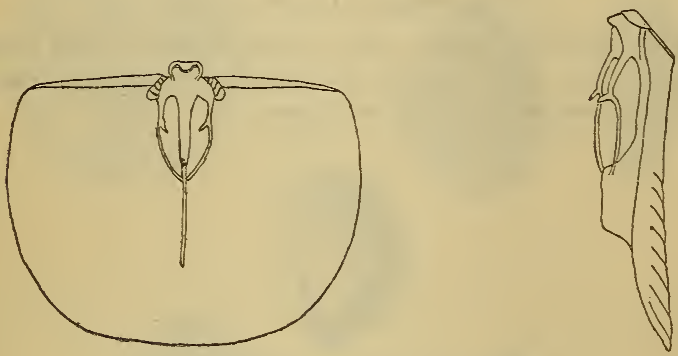
Tropidoleptus, Hall. 1857.

(Plate 54, figs. 1–11.)

Shells with the general external aspect of Rafinesquina; concavo–, or plano-convex. Hinge-line straight; in young shells forming the greatest transverse diameter and frequently extended at the cardinal extremities, but in mature and old shells shorter than the transverse diameter in the pallial region. Marginal outline varying from longitudinally semi-elliptical in youth, to transversely subelliptical at maturity. Surface covered with simple, low plications, all extending from beak to margins. The median plication on the pedicle-valve and the corresponding sinus on the brachial valve are broader and more conspicuous than the others.

The pedicle-valve is regularly convex, becoming slightly concave on the cardinal slopes. It bears a moderately broad cardinal area, coextensive with the hinge-line, which is divided by a broad, open delthyrium, which, in no observed condition of growth, bears a covering of any sort, but is filled by the cardinal process of the other valve. The base of the delthyrial cavity is thickened and transversely striated, probably by the attachment of the pedicle-muscle. The teeth are not situated at the extremities of the delthyrial margins, but lie within and in front of them, arise from the bottom of the valve as two erect, divergent subquadrate crests, resting upon low ridges which bound the muscular area. These peculiar teeth are smooth and abrupt on their inner faces, while their outer faces are deeply crenulated. A low groove separates each from the cardinal area. The muscular area is broadly flabellate, extending more than half way across the valve, and consists of two large diductor scars enclosing a narrow median pair of adductors.

The brachial valve is slightly concave, often nearly flat. Cardinal area narrow, but clearly developed; chilidium prominent. Cardinal process large, erect, smooth on its posterior surface, and bilobed at its summit. Each of these lobes is excavated above so that the upper portion of the posterior wall is free from the rest of the process. In front of this is a broad, smooth floor, sloping toward the bottom of the valve. The margins of this area form the elevated socket-walls, and their anterior extremities are the bases of the crura. The dental sockets are deep and their outer walls corrugated for the reception of the teeth. The posterior portion of the sockets and the lower part of the cardinal process are covered by the erect, convex chilidium. At the anterior edge of the cardinal process lies a broad, thick, not elevated median ridge, which gradually narrows and becomes developed



Tropidoleptus carinatus, Conrad.

FIG. 514. The interior of the brachial valve; showing the cardinal process, crenulated dental sockets, loop and median septum.

FIG. 515. The same in profile; showing the height of the median septum and the mode of attachment of the lamellæ of the loop.

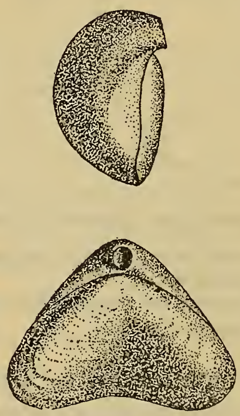
into a sharp, thin septum, attaining its highest point at about the center of the valve, whence it slopes rather more abruptly downward, terminating at the anterior third of the valve. From the crural bases extends a pair of long, slender lamellar processes, which curve outward, are directed upward, again converge and unite with the median septum on its lateral faces and just in front of its highest point. Slightly convergent, slender jugal processes are given off not far from the origin of the lateral lamellæ. The scars of the adductor muscles are situated just in front of the cardinal process on either side of the septum, and are not clearly delimited.

Shell-substance highly punctated in all its parts.
Type, *Tropidoleptus carinatus*, Conrad (sp.).
Distribution; Lower and middle Devonian.

Note.— In the treatment of the post-palæozoic genera of the terebratuloids it has seemed necessary and appropriate to defer to the opinions of other authors, and therefore desirable, at least for the purposes of the American student, to consider them separately from the palæozoic genera, following in a general way the accepted interpretation of their affinities, but not often expressing a judgment as to the generic value of their characters.

[?] Cruratula, Bittner. 1890.

Magellania-like shells, with median septum in the brachial valve, punctate shell, but with the lateral or descending branches of the loop not united, so far as known.



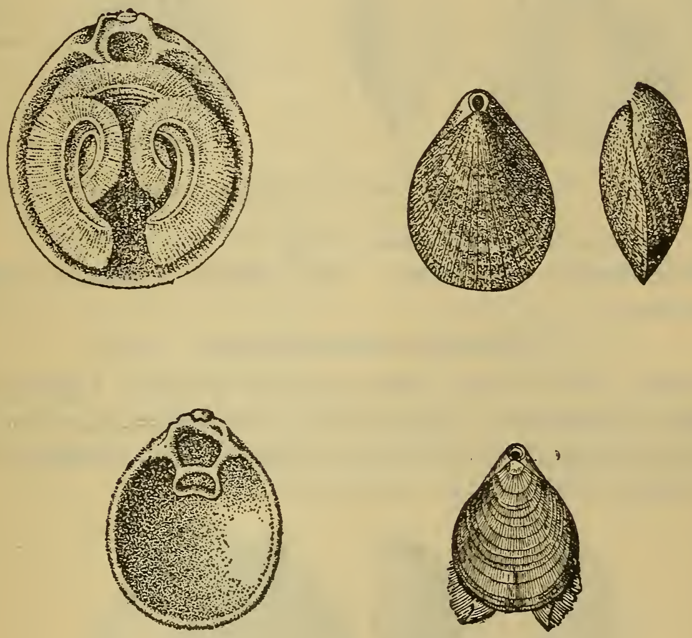
Figs. 516, 517. *Cruratula Eudora*, Laube (sp.). (Bittner.)

Type, *Cruratula Eudora*, Laube (sp.).
Distribution. Trias.

Terebratulina, d'Orbigny. 1847.

Shells biconvex; ovate in outline. Cardinal extremities faintly auriculate. Beak of pedicle-valve trunctated by a circular foramen; deltidial plates small. Surface finally radiate. Interior of pedicle-valve without dental plates. In the brachial valve the cardinal process is slightly developed; hinge-plate and median septum wanting; socket walls prominent, supporting a short loop which is rendered annular by the union of the oval processes.

Brachia as in LIOTHYRINA, the median unpaired arm being small. Each lobe of the mantle bears four sinuses; genital



FIGS. 518–522. *Terebratulina caput-serpentis*, Linné (sp.). (DAVIDSON; BARRETT.)

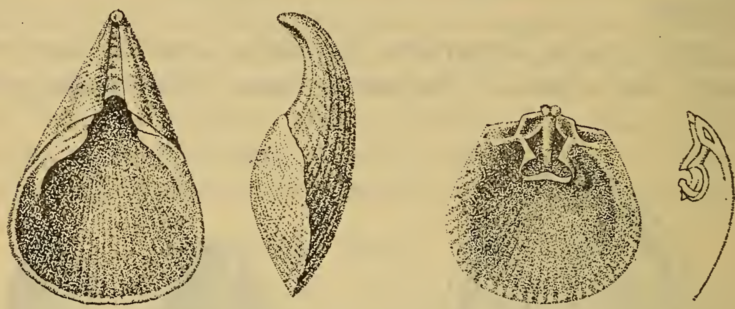
glands six, two in each mantle lobe and two in the visceral cavity.

Type, *Terebratulina caput-serpentis*, Linné (sp.).

Distribution. Jurassic — Recent (Arctic, Boreal, Lusitanian, West African, Indo-Pacific, Australo-Zealandian, Japanese, Aleutian, Californian, Magellanian, Caribbean and Transatlantic Provinces).

Subgenus Agulhasia, King. 1871.

Shells small, with highly elevated arcuate umbo, elongate-triangular false cardinal area divided by a median depression, the foramen lying at its base. Loop as in Terebratulina.

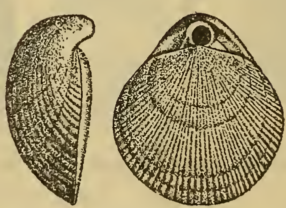


Figs. 523–526. *Agulhasia Davidsoni*, King. (Davidson.)

Type, *Agulhasia Davidsoni*, King.
Distribution. Cretaceous (?)—Recent (South African Province).

[?] Disculina, Deslongchamps. 1884.

Shells plano-convex; surface sharply plicated. Cardinal area distinctly developed; foramen large, encroaching upon the apex of the brachial valve. Cardinal process bilobed; accompanied by a divided chilidium (?). Loop not known.



Figs. 527, 528. *Disculina hemisphœrica*, Sowerby (sp.). (Davidson).

Type, *Disculina hemisphœrica*, Sowerby (sp.).
Distribution. Jurassic.

Terebratula, Klein. 1753.

Synonym; *Lampas*, Meuschen, 1787.
Shells elongate, biconvex, smooth. Apex of pedicle-valve broadly truncated; foramen circular. Brachial valve with two

broad plications most conspicuous at the margins. Loop probably short, with slightly recurved ascending lamellæ; jugal processes not united above.

(It has been shown by Douvillé that the term Terebratula, though introduced by Llhwyd in 1699, can only derive a definite significance from the determinations by Klein in 1753. Klein's first species is *T. simplex*, which is the same as the *Concha anomia* of Colonna (1676) and the last author's figure which is reproduced by Klein, and also inserted here, represents one of the extensive group of the *Terebratulæ biplicatæ*. From Linné's description of his *Anomia terebratula* (1758), which is also based upon this shell, it is inferred that the species thereby represented is a fossil from the Mesozoic or Tertiary formations, though its geological horizon is not more precisely known.)

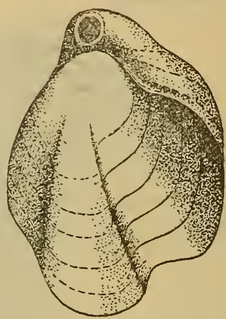
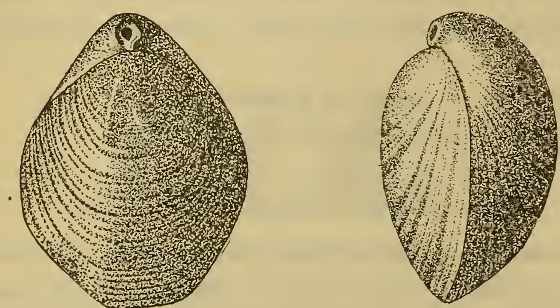


Fig. 529. *Terebratula simplex.* (Colonna, Klein, Œhlert.)

Liothyrina, Œhlert. 1887.

Synonym; *Liothyris*, Douvillé, 1880.

Shells biconvex, unplicated. Loop short, transverse lamella bent upward in the middle; oral process discrete; cardinal process small, hinge-plate divided. Muscular scars restricted to the posterior portion of both valves.



Figs. 530, 531. *Liothyrina vitrea*, Born (sp.). (Davidson.)

Animal with long, free brachia united at the base by a membranous expansion.

Type, *Liothyrina vitrea*, Born (sp.).

Distribution. Tertiary — Recent (Arctic, Lusitanian, West African, Indo-Pacific, Australo-Zealandian, Japanese, Californian, Panamic, Peruvian, Magellanian, Patagonian and Caribbean Provinces).

Eucalathis, Fischer and Œhlert. 1890.

Shell small, auriculate; valves convex, covered with radiating plications. In the interior are neither dental plates nor septa. Cardinal process distinct. Loop short; descending branches with oral processes distinct, and directly in front of them the lamellæ are deflected into a transverse band which

Figs. 532, 533. *Eucalathis Murrayi*, Davidson (sp.). (Davidson.)

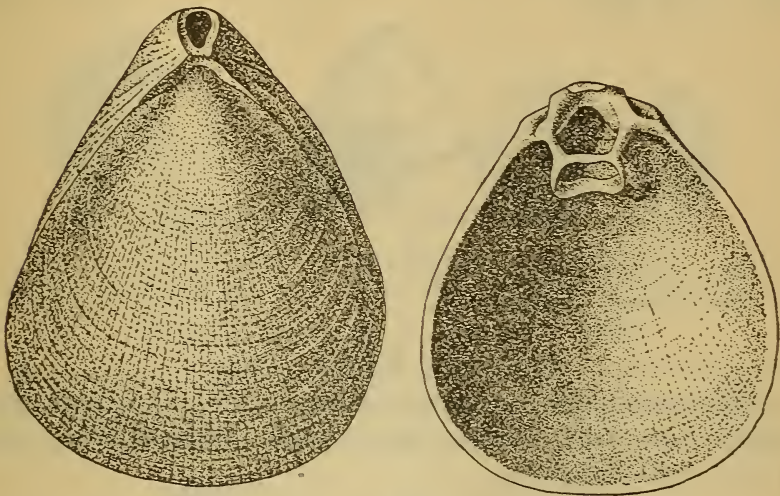
bears a narrow median fold. Brachia but slightly developed, scarcely longer than the loop and arranged in two lobes.

Type, *Eucalathis Murrayi*, Davidson (sp.).

Distribution. Recent (Lusitanian Province).

Dyscolia, Fischer and Œhlert. 1890.

Shells of large size, subtrigonal, faintly auriculate; valves convex with radiating surface striæ. Beak short, foramen large, deltarium concave, transversely striated, much thickened in old shells. On the interior neither septum nor dental plates. In the brachial valve there is no hinge plate. Loop broad and short, descending processes united anteriorly by a transverse band as in Liothyrina. Brachia represented by a subrectangular brachial disk, slightly bilobed in front and extending beyond the loop for one-third of its length. This disk is bordered by cirri.

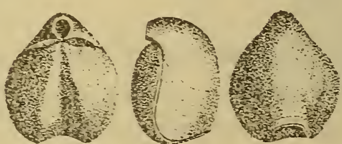


FIGS. 534, 535. *Dyscolia Wyvillii*, Davidson (sp.). (DAVIDSON.)

Type, *Dyscolia Wyvillii*, Davidson (sp.).
Distribution. Recent (West African and Caribbean provinces).

Subgenus Glossothyris, Douvillé. 1880.

Shells like LIOTHYRINA but with a deep median sinus on the brachial valve. Loop short, anterior transverse band slightly recurved.



FIGS. 536–538. *Glossothyris nucleata*, Schlotheim (sp.). (QUENSTEDT.)

(Type, *Glossothyris nucleata*, Schlotheim (sp.). Jurassic.)

Pygope, Link. 1830.

Synonyms; *Antinomia*, Catullo, 1850; *Pugites*, de Haan, 1833.
Shells normally biconvex when young, but with increasing age the median growth of the valves is arrested, and by the continued

growth of the lateral portions the shell becomes bilobed, the two lobes inclosing a perforation situated posteriorly in the median line. Loop short.

[Fig. 539. *Pygope diphya*, Colonna (sp.). (Woodward).

Type, *Pygope diphya*, Colonna (sp.).
Distribution. Jurassic.

Propygope, Bittner. 1890.

Shells small with the naviculoid contour of Aulacothyris but with a short loop. Dental plates absent. Brachial valve with a short median septum.

Figs. 540–543. *Propygope Hagar*, Bittner. (Bittner.)

Type, *Propygope Hagar*, Bittner.
Distribution. Trias.

Subgenus Zugmayeria, Waagen. 1882.

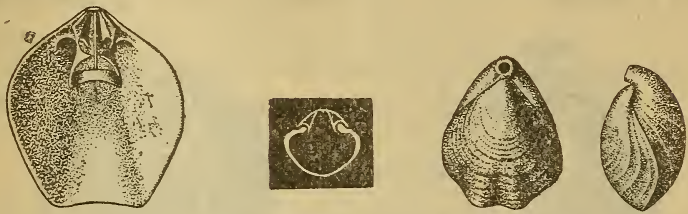
Shells biplicate; loop short; with strong dental plates and without crural plates.

Figs. 544–547. *Zugmayeria rhœtica*, Zugmayer (sp.). (Zugmayer.)

Type, *Zugmayeria rhœtica*, Zugmayer (sp.).
Distribution. Triassic.

Subgenus **Rhaetina**, Waagen. 1882.

Shells biplicate; loop short, supported by crural plates; dental plates absent.

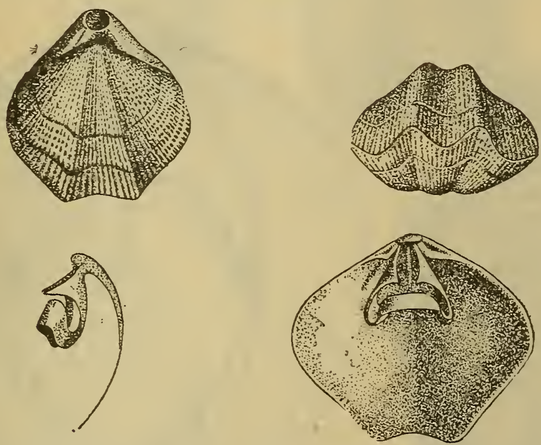


Figs. 548–551. *Rhaetina gregaria*, Suess (sp.). (Zugmayer.)

(Type, *Rhaetina gregaria*, Suess (sp.). Triassic.)

Subgenus **Dictyothyris**, Douvillé. 1880.

Shells subnaviculate, with median fold and sinus on brachial and pedicle-valves respectively. Surface covered with short spinules. Dental plates are present in the pedicle-valve. In the



Figs. 552–555. *Dictyothyris coarctata*, Parkinson (sp.). (Davidson.)

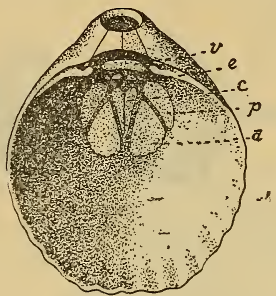
brachial valve is a well-developed cardinal process and faint median septum; the loop is short, its anterior band being broad and considerably reflected.

(Type, *Dictyothyris coarctata*, Parkinson (sp.). Jurassic.)

Magellania, Bayle. 1880.

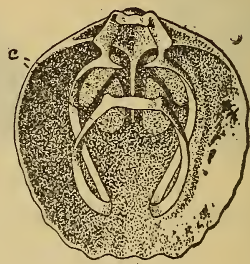
Synonym; *Waldheimia*, King. 1850; *Neothyris*, Douvillé. 1880.

Shells biconvex, ovate or subpentagonal. Surface plicate or smooth. Beak of the pedicle-valve broadly truncated. Deltidial plates well developed. Pedicle-valve without dental plates. In the brachial valve is a conspicuous trilobed cardinal process and a hinge-plate supported by a median septum which may be more or less developed. Loop long, extending nearly to the anterior



a

Fig 556.



b

Fig. 557.

Figs 557, 558. *Magellania flavescens.* *a*, pedicle-valve; *b*, brachial valve; *c*, adductor scars; *d*, diductors; *e*, accessory diductors; *p*, ventral pedicle-muscle; *v*, median pedicle-muscle. (Davidson.)

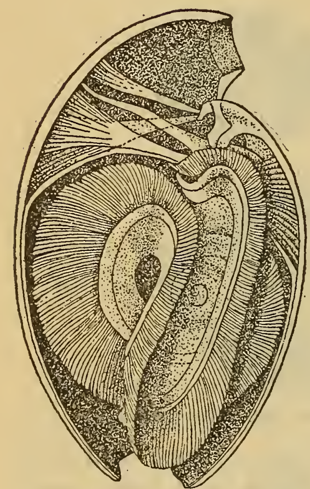


Fig. 558.

Fig. 559. *Magellania flavescens*, showing the brachia. (Davidson.)

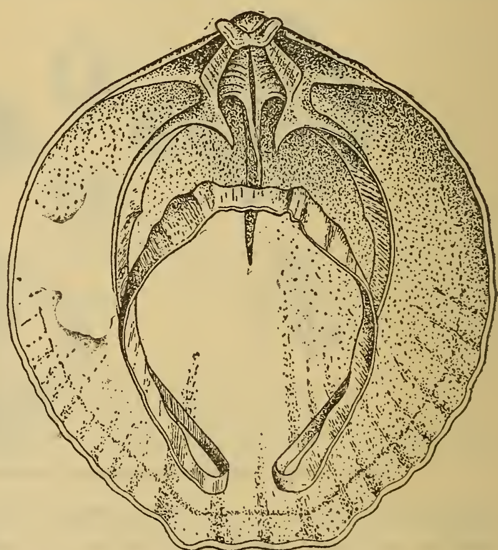


Fig. 559.

Fig. 560. The brachial supports of *Magellania flavescens.* (Hancock.)

margins of the valves ; oral processes large, not united ; ascending branches extending backward to or beyond the center of the shell and united by a stout transverse lamella. Muscular area posterior in both valves.

Mantle with four trunk sinuses on each lobe; of the genital glands two pairs lie in the dorsal lobe and four in the ventral lobe. Structure and arrangement of the brachia as in Terebratulina.

Type, *Magellania flavescens*, Lamarck (sp.).

Distribution. Jurassic — Recent (Arctic, Australo-Zealandian, Japanese, Peruvian and Magellanian Provinces).

Dallina, Beecher. 1893.

Magellaniiform shells, with long, recurved loop, small cardinal process and well developed dorsal median septum. The adult condition of the loop is attained by a series of metamorphoses in

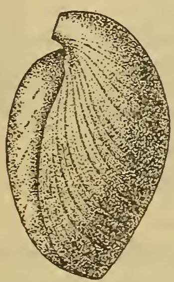


Fig. 560.

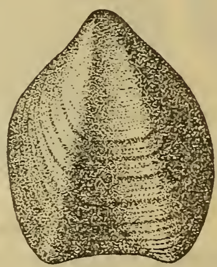


Fig. 561.

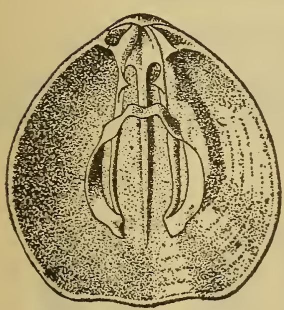


Fig 562.

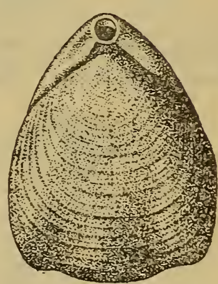


Fig. 563.

Figs. 560–563. *Dallina septigera*, Lovén (sp.).

immature conditions resembling successively the mature brachidium in Platidia, Ismenia and Mühlfeldtia.

Type, *Dallina septigera*, Lovén (sp.).

Distribution. Tertiary — Recent (Arctic, Boreal, Lusitanian, Japanese and Transatlantic Provinces).

Cœnothyris, Douvillé. 1880.

Shells elongate-oval, smooth. Dental plates highly developed, becoming calloused with age. Hinge-plate large, tripartite and supported by a median septum extending one-half the length of the shell. Cardinal process absent or very faint. Loop broad

Fig. 564, *Cœnothyris vulgaris*, Schlotheim (sp.). (Koschinsky.)

and moderately long, the ascending branches forming at their union a shield-shaped plate which is not attached to the median septum.

Type, *Cœnothyris vulgaris*, Schlotheim (sp.).

Distribution. Trias.

Hynniphoria, Suess. 1858.

Small, subglobular smooth shells said to contain a "plowshare"-shaped process on the brachial apparatus. Imperfectly known.

Type, *Hynniphoria globularis*, Suess. Jurassic.

Macandrevia, King. 1859.

Shells biconvex, smooth, elongate-oval. Foramen large and without deltidial plates. Pedicle-valve with dental plates.

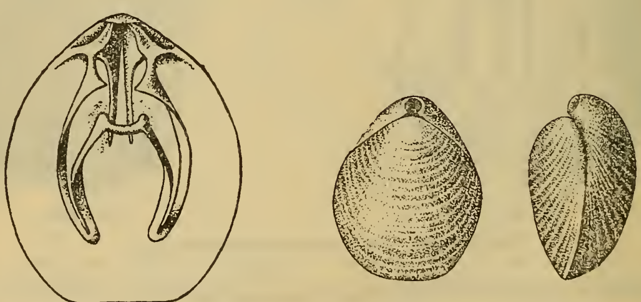


Fig. 565. Fig. 566. Fig. 567.

Figs. 565–567. *Macandrevia cranium*, Müller (sp). (Davidson.)

Brachial valve without cardinal process, but with crural plates and sometimes the remnant of a median septum. Loop in its mature condition similar to that of Magellania.

Type, *Macandrevia cranium*, Müller (sp.).

Distribution. Recent (Boreal, Lusitanian and Japanese Provinces.)

Subgenus **Zeilleria**, Bayle. 1878.

Shell with biplicate brachial valve, dental plates and long loop.

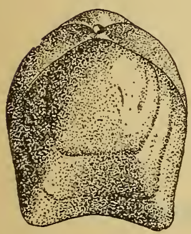


Fig. 568.

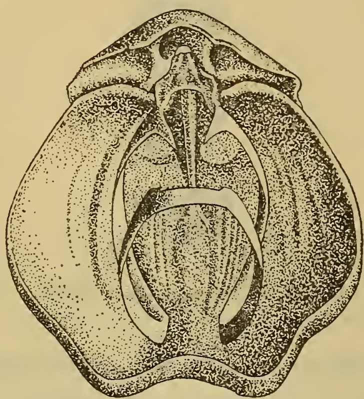


Fig. 570.

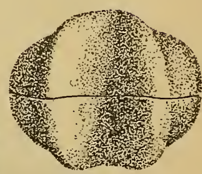


Fig. 569.

Figs. 568-570. *Zeilleria cornuta*, Sowerby (sp.). (Davidson.)

(Type, *Zeilleria cornuta*, Sowerby (sp.). Jurassic.)

Subgenus **Fimbriothyris**, Deslongchamps. 1884.

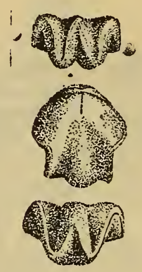
Shells biconvex, elongate, smooth in early growth, developing marginal angular plications at maturity.

Figs. 571, 572. *Fimbriothyris Guerangeri*, Deslongchamps (sp.). (Quenstedt.)

(Type, *Fimbriothyris Guerangeri*, Deslongchamps, Jurassic.)

Subgenus **Antiptychina**, Zittel. 1883.

Shells elongate, brachial valve with broad median sinus, having elevated margins and a stout plication at its base. Dental plates and median dorsal septum well developed. Loop long and fimbriate.



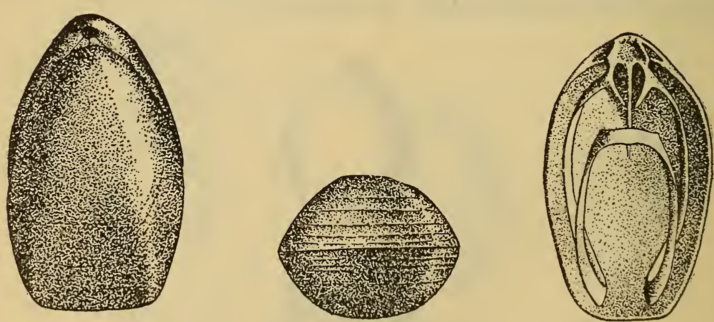
Figs. 573-575. *Antiptychina inversa,* Quenstedt (sp.). (Quenstedt.)

(Type, *Antiptychina bivallata,* Deslongchamps (sp.). Jurassic—Cretaceous.)

Subgenus **Microthyris**, Deslongchamps. 1884.

Synonym; *Ornithella,* Deslongchamps, 1884.

Elongate-oval shells with smooth surface, abrupt anterior slopes, dental plates and long loop.



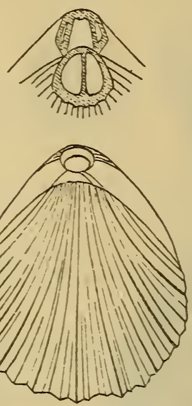
Figs. 576-578. *Microthyris lagenalis,* Schlotheim (sp.). (Davidson.)

(Type, *Microthyris lagenalis,* Schlotheim (sp.). Jurassic.)

Subgenus **Eudesia**, King. 1850.

Synonym; *Flabellothyris*, Deslongchamps, 1884.

Biconvex shells, with dental plates, median dorsal septum, long recurved loop and sharply plicated exterior.



FIGS. 579, 580. *Eudesia cardium*, Lamarck (sp.) (DOUVILLÉ.)

(Type, *Eudesia cardium*, Lamarck (sp.). Jurassic.)

Subgenus **Orthotoma**, Quenstedt. 1871.

Shells small, subcircular, biconvex, smooth, with marginal median sinus on the brachial valve. Hinge-line straight.

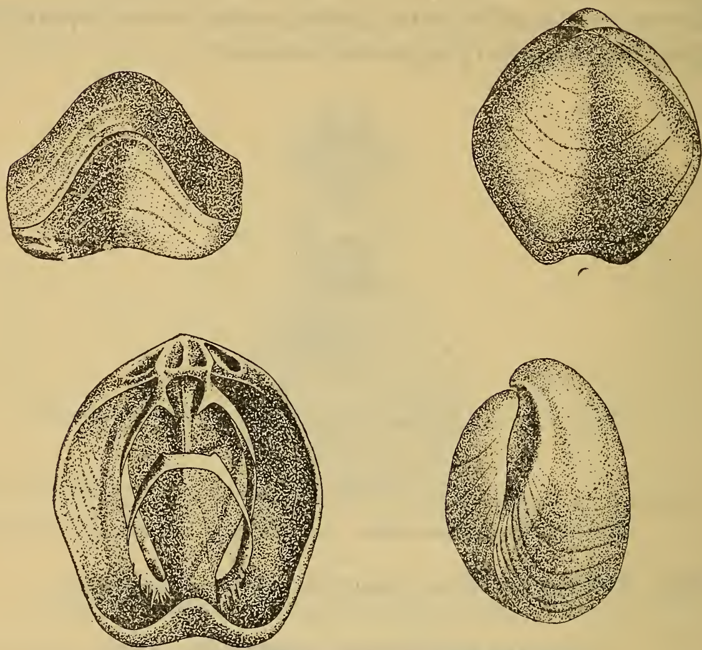
FIGS. 581, 582. *Orthotoma Heyseana*, Dunker (sp.). (QUENSTEDT.)

(Type, *Orthotoma Heyseana*, Dunker (sp.). Jurassic.)

Subgenus **Aulacothyris**, Douvillé. 1880.

Shells smooth, naviculoid in contour; brachial valve with a broad median sinus, pedicle-valve with conspicuous median ridge. Dental plates and dorsal median septum well developed. Loop long, fimbriate.

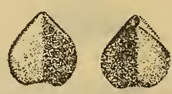
(Type, *Aulacothyris resupinata*, Sowerbv (sp.). Trias — Cretaceous.)



Figs. 583-586. *Aulacothyris resupinata*, Sowerby (sp.). (Davidson.)

Subgenus **Epicyrta**, Deslongchamps. 1884.

Smooth naviculoid shells with broad median sinus on pedicle-valve and corresponding elevation on the brachial valve.



Figs. 587, 588. *Epic rta Eugenii*, von Buch (sp.). (Quenstedt.)

(Type, *Epicyrta Eugenii*, von Buch (sp.). Jurassic.)

Subgenus **Plesiothyris**, Douvillé. 1880.

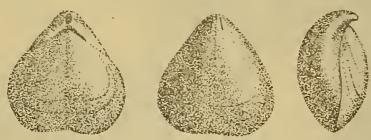
Shells biconvex, brachial valve biplicate. Dental plates and dorsal median septum present. Loop long.

(Type, *Plesiothyris Verneuilii*, Deslongchamps (sp.). Jurassic.)

Subgenus Camerothyris, Bittner. 1890.

Shells with the contour and loop of Aulacothyris, but having the dental plates convergent and united.

(Type, *Camerothyris Ramsaueri*, Suess (sp.). Trias.)



Figs. 589-591. *Camerothyris Ramsaueri*, Suess (sp.) (Bittner.)

(It is suggested by Œhlert that the genus Orthoidea, Friren, 1875, is based on young shells of *Magellania numismalis*, Lamarck. Lias.)

Terebratalia, Beecher. 1893.

Magellaniiform shells, having the adult loop of precisely similar structure to that of Terebratella, but derived through a dissimilar series of metamorphoses, namely, through stages corresponding successively with the adult condition in Platidia, Ismenia and Mühlfeldtia.

Figs. 592-594. *Terebratalia transversa*, Sowerby (sp.). (Davidson.)

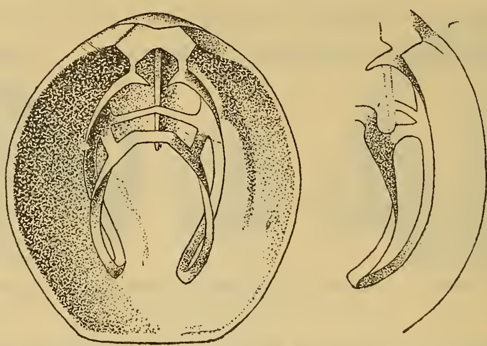
Type, *Terebratalia transversa*, Sowerby (sp.).

Distribution. Recent (Arctic, Boreal, Japanese, Aleutian and Californian Provinces).

Laqueus, Dall. 1870.

Synonym; *Frenula*, Dall, 1871.

Shells differing from Terebratella only in the structure of the loop, which bears two lateral processes, connecting the ascending branches near the transverse band with the descending branches just in front of the oral processes.



Figs. 595, 596. *Laqueus Californicus*, Koch (sp.). (Davidson.)

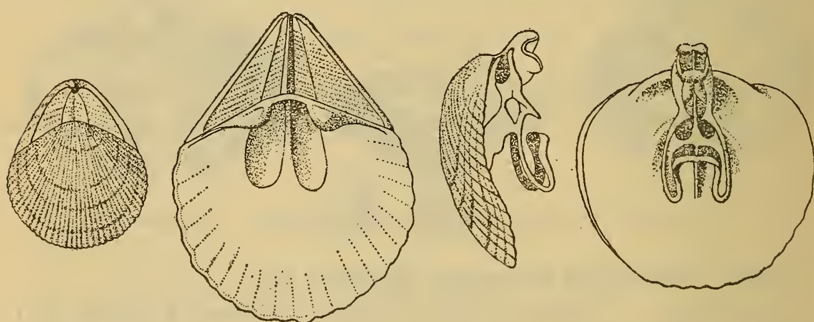
Type, *Laqueus Californicus* Koch (sp.).

Distribution. Recent (Boreal, Japanese and Californian Provinces).

Trigonosemus, Kœnig. 1825.

Synonyms; *Fissurirostra*, d'Orbigny, 1847; *Fissirostra*, d'Orbigny, 1848; *Delthyridea*, King, 1850.

Shells planoconvex; surface radially plicate. Pedicle-valve with arched and prominent beak, sharply defined cardinal area, and minute apical foramen bounded beneath by coalesced deltidial plates. Cardinal process highly developed, bilobed. Loop as in Terebratella, but more narrow and elongate.



Figs. 597–600. *Trigonosemus elegans*, Kœnig. (Davidson.)

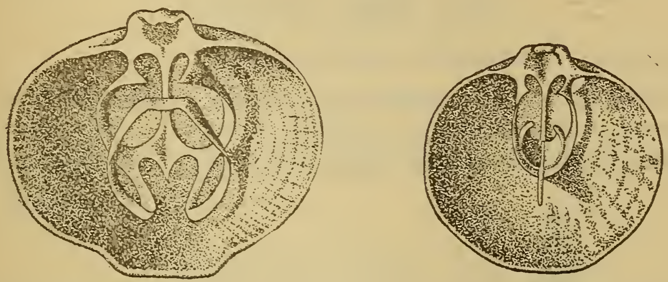
Type, *Trigonosemus elegans*, Kœnig.

Distribution. Cretaceous.

Terebratella, d'Orbigny. 1847.

Synonym; *Waltonia*, Davidson, 1850.

Shells biconvex, oval; surface plicate, rarely smooth. Cardinal area more or less distinctly defined on the pedicle-valve; foramen large, deltidial plates usually not united at maturity. Dental plates and sometimes a faint median septum are present. Brachial valve



FIGS. 601, 602. *Terebratella dorsata*, Gmelin (sp.); showing the mature and an immature condition of the loop. (DAVIDSON.)

with prominent cardinal process and divided hinge-plate. Loop long and recurved, the descending processes joined with the median septum by a pair of lateral lamellæ passing obliquely backwards.

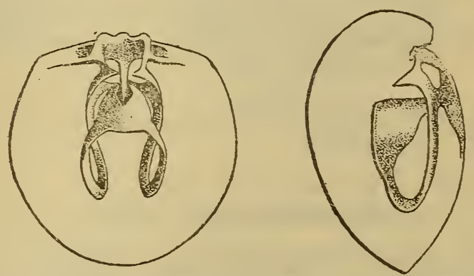
Type, *Terebratella dorsata*,* Gmelin (sp.).

Distribution. Jurassic — Recent (Australo Zealandian, Californian, Peruvian and Magellanian Provinces).

Kingena, Davidson. 1852.

Synonym; *Kingia*, Schloenbach, 1867.

Shell subglobose, smooth or tuberculated. Foramen circular, deltidial plates rudimentary. Pedicle-valve with dental plates;



FIGS 603, 604. *Kingena lima*, Defrance (sp.). (WOODWARD.)

brachial valve with broad cardinal process and a median septum. Loop long, recurved, as in TEREBRATELLA, but with the dorsal band

* On pp. 15, 17 and 76 this species is erroneously referred to as *Terebratalia dorsata*.

situated posteriorly, and the transverse band of the ascending branches developed into a broad saddle, the posterior margin of which incloses the median septum.

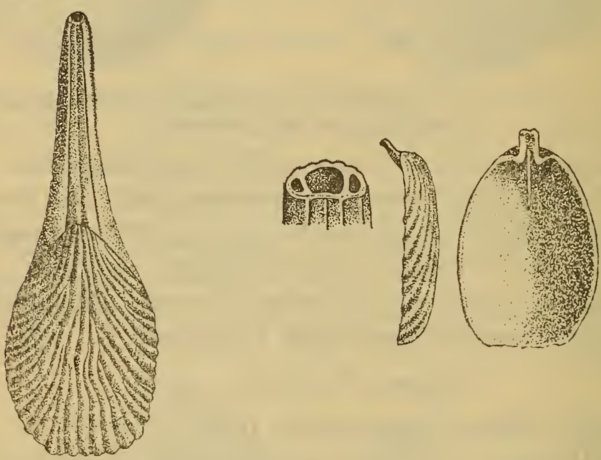
Type, *Kingena lima*, Defrance (sp.).

Distribution. Cretaceous.

Lyra, Cumberland. 1816.

Synonym; *Terebrirostra*, d'Orbigny, 1847.

Plicated shells with the umbo of the pedicle-valve extravagantly elongated, terminating in an apical foramen. Deltidial plates very large; dental plates highly developed. Loop as in Terebratella in immature stages, the connecting lamellæ disappearing at maturity.



Figs. 605–608. *Lyra Meadi*, Cumberland. (Davidson.)

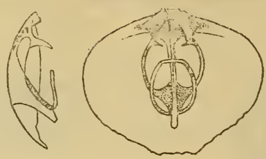
Type, *Lyra Meadi*, Cumberland.

Distribution. Cretaceous.

Magasella, Dall. 1870.

Shells exteriorly as in Terebratella. Brachial valve with a highly developed median septum whose anterior extremity is elevated and free. Descending branches of the loop attached to this septum by broad expansions of the lamellæ; ascending branches forming a distinct ring, attached at its base to the median septum a short distance above the insertion of the descending branches.

Type, *Magasella Adamsi*, Davidson (sp.).



FIGS. 609, 610. *Magasella Adamsi*, Davidson (sp.). (WOODWARD.)

Distribution. Recent (Australo-Zealandian, Japanese, Aleutian and Magellanian Provinces.)

Mühlfeldtia, Bayle. 1880.

Synonym; *Megerlia*, King, 1850.

Shells transverse or elongate, the transverse forms having a straight hinge-line and a well-developed cardinal area on each valve. Beaks low, foramen large, deltidial plates incomplete. Surface radiate. Cardinal process large. In the loop the descending processes unite anteriorly with the ascending branches, the latter being joined at their base to the median

FIGS. 611–613. *Mühlfeldtia truncata*, Linné (sp.). (DAVIDSON.)

septum, whence they bend forward and recurve. The lateral or basal portions of the ring thus formed are expanded and, in final stages of development, broadly perforated. Internal surface of the valves covered with radiating rows of pustules.

Type, *Mühlfeldtia truncata*, Linné (sp.).

Distribution. Tertiary — Recent (Lusitanian, West African, Indo-Pacific, Australo-Zealandian and Japanese Provinces.)

Ismenia, King. 1850.

Shells coarsely plicate with low umbones, large foramen and no cardinal area. Loop with descending and ascending branches coalesced with the median septum. The descending branches

Figs. 614–616. *Ismenia pectunculoides*, Schlotheim (sp.). (Quenstedt.)

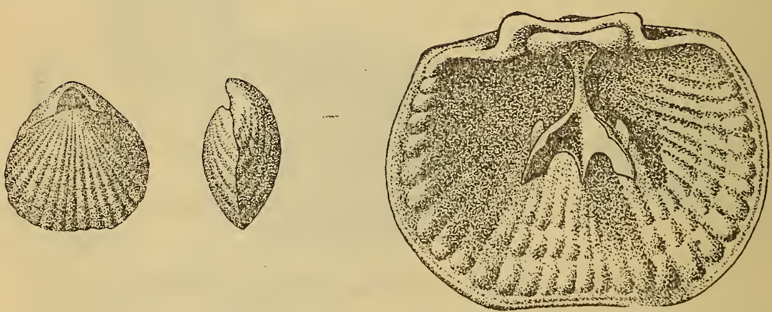
form a ring whose anterior margins are fimbriate and are produced into two fimbriate anterior extensions.

Type, *Ismenia pectunculoides*, Schlotheim (sp.).

Distribution. Jurassic.

Megerlina, Deslongchamps. 1884.

Shells exteriorly as in Mühlfeldtia; the loop, however, differs in the abbreviation of the descending lamellæ, the anterior portions being attached to the median septum, and the crural pro-



Figs. 617–619. *Megerlina Lamarckiana*, Davidson (sp.). (Davidson)

cesses not united. The anterior attachment of the ascending lamellæ to the septum is also modified or incomplete.

Type, *Megerlina Lamarckiana*, Davidson (sp.).

Distribution. Recent (South Africa and Australo-Zealandian Provinces).

Bouchardia, Davidson. 1849.

Synonym; *Pachyhrynchus*, King, 1850.

Shells elongate-oval; surface smooth. Beak of the pedicle-valve elevated, subacute, truncated by a circular foramen. Deltidial plates coalesced, concave. Interiorly both valves much thickened in the umbonal region. Teeth and sockets much abbreviated. In the pedicle-valve the adductor and diductor scars are situated anteriorly and divided by a low median ridge.

Figs. 620-622. *Bouchardia rosea*, Mawe (sp.). (Davidson.)

In the brachial valve is an elongate rectangular bilobed cardinal process, which fits into the deep pedicle-groove of the opposite valve. Median septum developed anteriorly. Brachidium without the descending branches; ascending branches represented by two broad, curved triangular processes coalesced with the septum below and not uniting above.

Type, *Bouchardia rosea*, Mawe (sp.).

Distribution. Recent (Caribbean Province).

Magas, Sowerby. 1816.

Shells small, subplano-convex. Surface smooth. Pedicle-valve deep, with incurved umbo. Foramen subtriangular, deltidial plates feebly developed. Brachial valve with a well-developed cardinal process, and very prominent median septum. Descending branches of the loop joined to the walls of this septum; above their insertion arise the ascending processes which are broad, concave, triangular plates, with their apices tapering backward but not uniting.

Figs. 623–626. *Magas pumilus*, Sowerby. (Davidson.)

Type, *Magas pumilus*, Sowerby.
Distribution. Cretaceous.

Rhynchora, Dalman. 1828.

Shell elongate-ovate, coarsely plicate. Hinge-line short, straight. Foramen large, subcircular, deltidial plates wanting. Teeth, sockets and cardinal process well developed. A low median septum in each valve. Loop not known.
Type, *Rhynchora costata*, Wahlenberg (sp.).
Distribution. Cretaceous.

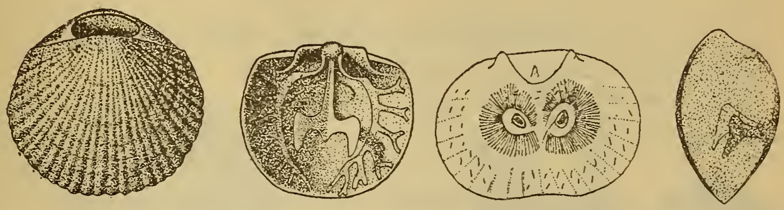
Rhynchorina, Œhlert. 1887.

Shells small, transverse, the hinge line, which is straight, making the greatest diameter of the valves. Umbones very depressed. Surface smooth. Teeth and sockets placed at the cardinal extremities. Brachial valve with a broad cardinal plate or area extending for the entire length of the hinge; at its center is a callosity or cardinal process, which is supported by a median septum. Loop like that of Magas.
Type, *Rhynchorina spathulata*, Wahlenberg (sp.).
Distribution. Cretaceous.

Kraussina, Davidson. 1859.

Synonym; *Kraussia*, Davidson, 1852.
Shells biconvex, plicate, subcircular or oval; hinge-line straight; foramen large, deltidial plates incomplete. Interior of the brachial valve with cardinal process and median septum. Brachi-

dium reduced to two lateral expanded processes arising from the elevated anterior portion of the septum and representing the ascending process.



Figs. 627–630. *Kraussina rubra*, Pallas (sp.). (Davidson.)

Type, *Kraussina rubra*, Pallas (sp.).

Distribution. Recent (South African and Australo-Zealandian Provinces).

Mannia, Dewalque. 1874.

Small magadiform shells, with the brachidium consisting of two descending processes, not uniting with the median septum, the latter bearing at its extremity two disunited lamellæ which represent the ascending branches.

Type, *Mannia Nysti*, Dewalque.

Distribution. Miocene.

Platidia, Costa. 1852.

Shells small, biconvex, smooth, with large punctures. Foramen large, encroaching on both valves; no deltidial plates. Teeth and sockets small. In the brachial valve the median septum is reduced to a vertical plate which rises near the center of the

Figs. 631–633. *Platida anomioides*, Scacchi. (Davidson.)

valve. To this plate the descending branches of the loop are united; ascending branches not represented; brachia in three lobes, the median lobe surrounding the oral orifice and not spirally coiled.

Type, *Platidia anomioides*, Scacchi (sp.).

Distribution. Recent (Lusitanian, Californian, Magellanian, Caribbean and Transatlantic Provinces).

Megathyris, d'Orbigny. 1847.

Synonym; *Argiope*, Deslongchamps, 1842.

Shells transversely elongate; hinge-line long and straight, equaling the greatest diameter of the valves. Cardinal area well developed on both valves. Foramen large, oval, deltidial plates small. In the pedicle-valve there is a median septum and two low lateral septa. Brachial valve with prominent cardinal process, and three or five septa lying in front of the visceral region. Of these, one septum is median. Brachidium consisting of a simple continuous lamellæ with broad oral processes and divided into four lobes by the median and first pair of lateral septa. The brachial disk is likewise divided into four lobes.

Figs. 634, 635. *Megathyris decollata*, Chemnitz (sp.). *n*, foramen; *o*, deltidial plates; *g*, crura; *l*, lobed extension of brachial supports. (Bronn.)

Type, *Megathyris decollata*, Chemnitz (sp.).

Distribution. Jurassic — Recent (Lusitanian Province).

Cistella, Gray. 1850.

Exteriorly like Megathyris. Interior of the valves with median but no lateral septa. Brachial lamella bilobed by the median septum to which it is partially attached.

Figs. 636-638. Cistella cuneata, Risso (sp.). Davidson.

Type, *Cistella cuneata*, Risso (sp.).

Distribution. Cretaceous — Recent (Boreal, Lusitanian and Caribbean Provinces).

Zellania, Moore. 1854.

Shells minute, subtriangular, impunctate. Hinge-line short, straight, with cardinal area on each valve. Foramen large, encroaching on the brachial valve. Median septum in each valve. In the brachial valve is a broad pustulose marginal area,

FIGS. 639, 640. *Zellania Davidsoni*, Moore. (DAVIDSON.)

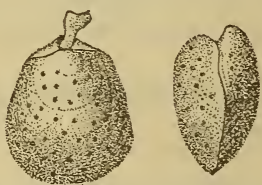
the inner edge of which is thickened into a ridge, bilobed by the median septum.

Type, *Zellania Davidsoni*, Moore.

Distribution. Lias.

Gwynia, King. 1859.

Shell thin, minute, biconvex, elongate-oval. Hinge-line short, nearly straight. Foramen large, with incomplete deltidial plates. Interior without septa or loop. Brachia forming an uninterrupted circlet, the anterior cirri of which are but slightly developed.



FIGS. 641, 642. *Gwynia capsula*, Jeffreys (sp.). (DAVIDSON.)

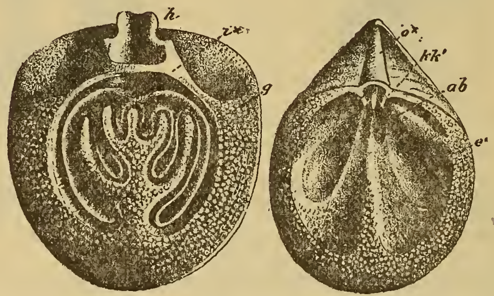
Type, *Gwynia capsula*, Jeffreys (sp.).

Distribution. Recent (Lusitanian Province).

Thecidea, Defrance. 1822.

Synonym; *Thecidium*, Sowerby. 1824.

Shells plano-convex, elongate-oval; surface covered with radiating rows of granules. Pedicle-valve with elevated beak, which is somewhat incurved over the broad, arched cardinal area. Deltidium conspicuously developed. Interior of both valves with broad, thickened granulose marginal areas. In the pedicle-valve the teeth are small and parallel; the adductor muscles rest upon a short median plate lying directly in front of the deltidium, at each side of which is the transversely oval scar of the diductors. Visceral area large, smooth and divided medially by a granulated



Figs. 643, 644. *Thecidea radiata*, o, deltidium; *kk*, teeth; *ab*, adductors, *e*, diductors; *h*, cardinal process; *i*, cardinal plate; *g*, brachial supports. (Suess.)

ridge. In the brachial valve the cardinal process is large, erect and subtriangular. The median septum branches repeatedly from its posterior extremity forward, and this forms a series of depressions or grooves of unequal length in which lay the lobes of the brachia.

Type, *Thecidea papillata*, Schlotheim (sp.).

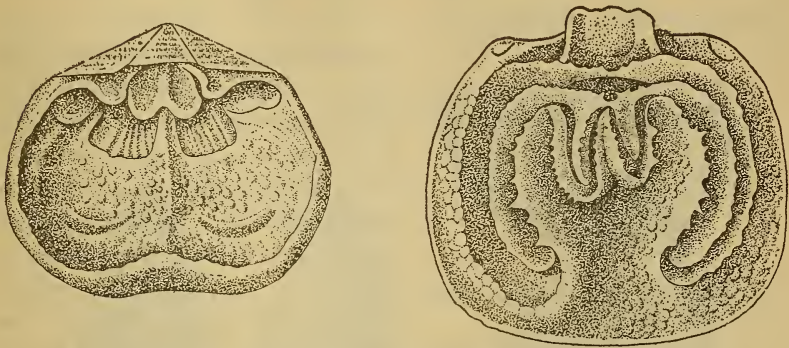
Distribution. Cretaceous.

Subgenus Lacazella, Munier–Chalmas. 1880.

Shells subtrigonal, solidly attached by the apex of the pedicle valve; surface smooth or with concentric growth lines. Pedicle-valve with conspicuous cardinal area and deltidium; muscular plate concave, small, free at its anterior extremity. In the brachial valve the cardinal process is strong, subrectangular, concave toward the base, and projected beyond the hinge. The cavities of the brachial lobes in two or three unequal pairs.

Animal with short alimentary canal; embryos developed in a pouch or marsupium situated at the bottom of the pedicle-valve, and attached to the brachia by a pair of long cilia.

(Type, *Lacazella Mediterranea*, Risso (sp.). Recent (Mediterranean); Fossil; Jurassic.— Tertiary.)



Figs. 645, 646. *Lacazella Mediterranea*, Risso (sp.). (Davidson).

Subgenus **Thecidiopsis**, Munier-Chalmas. 1887.

Interior of the brachial valve bearing a median septum with many branches and simple lateral marginal septa. Internal surface, septa and brachial lamella covered with granulations.

Figs. 647-649. *Thecidiopsis digitata*, Sowerby (sp.). (Quenstedt.)

(Type, *Thecidiopsis digitata*, Sowerby (sp.). Cretaceous.)

Subgenus **Thecidella**, Munier-Chalmas. 1887.

Shells subtrigonal, generally transverse; with straight hinge-line, well-developed cardinal area and deltidium. In the brachial valve the median septum is broad, elevated on its lateral

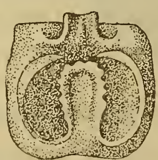


Fig. 650. *Thecidella Normaniana*, Munier-Chalmas. (Œhlert.)

margins, concave on its upper surface and irregularly perforated. Lateral lobes of the brachial lamellæ simple.

(Type, *Thecidella Normaniana*, Munier-Chalmas. Lias.

Eudesella, Munier–Chalmas. 1880.

Shells transverse, with long, straight hinge. Cardinal area and deltidium well developed. Pedicle-valve moderately deep; muscular scars posterior and thickened. Divisions of the internal surface corresponding to those of the opposite valve. Brachial valve flat; cardinal process prominent, subrectangular. Median septum extending from the anterior border to the cardinal region; two shorter lateral septa lie on each side. Brachial lamellæ following the lobes formed by the septa.

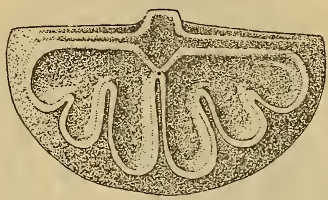


Fig 651 *Eudesella Mayalis*, Deslongchamps (sp) (Œhlert.)

Type, *Eudesella Mayalis*, Deslongchamps (sp.).

Distribution. Lias.

Bactrynium, Emmrich, 1855.

Synonym; *Pterophloios*, Gümbel. 1861.

Shells elongate, plano-convex; attached by the apex of the pedicle-valve. Surface smooth or with concentric striæ. Shell substance punctate. Pedicle-valve highly convex. On the interior is a low median septum in the umbonal region. In the brachial valve the cardinal process is well developed. The median septum begins near the anterior margin of the shell and extends backward almost to the base of the cardinal process. On each side are from eight to ten short transverse or convergent septa, together forming a series of lobes which are bounded by the brachial lamella.

Fig. 652. *Bactrynium Emmrichi*, Gümbel. (Hœrnes)

Type, *Bactrynium Emmrichi*, Gümbel (sp.).

Distribution. Lias.

Davidsonella, Munier–Chalmas. 1880.

Shells small, plano-convex, elongate or subquadrangular; attached by the umbo of the pedicle-valve which may thereby become deformed or truncated. Cardinal area and deltidium well developed. Pedicle-valve with two strong, approximate teeth; subcardinal muscular plate divided by a vertical lamella and supported by a median septum. In the brachial valve the cardinal process is prominent, concave on its inner surface and lies in the plane of the valve. The median septum is broad, acute at its anterior extremity. Between each of its lateral walls and the marginal border of the valve are elongate depressions filled with a loose tissue of calcareous spicules.

FIGS. 653–655. *Davidsonella sinuata*, Deslongchamps (sp.). (DESLONGCHAMPS.)

Type, *Davidsonella sinuata*, Deslongchamps (sp.).
Distribution. Lias.

Lyttonia, Waagen. 1883.

Shells of great size, highly inequivalve and very irregular; frequently with broad lateral expansions.

Pedicle valve convex, thick; apex not distinct; hinge-line short and straight; teeth faintly developed. On the interior are numerous ridges extending in slight curves toward the lateral margins; in the median line a smooth space bearing a central vertical ridge. Brachial valve operculiform, not extending to the margins of the opposite valve. Cardinal process small and bilobed; median surface of the interior with divergent grooves corresponding with the ridges of the other valve.

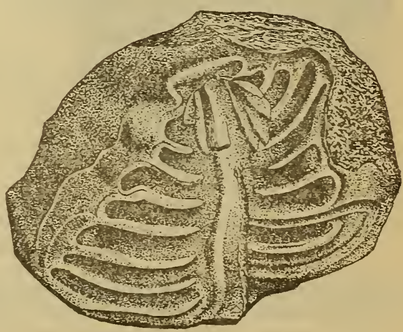


FIG. 656.
Lyttonia nobilis, Waagen.
FIG. 656. Cardinal part of a pedicle-valve; showng the hinge-line, median and lateral septa. (WAAGEN.)

External surface covered with flexuous lines of growth.

Shell-substance punctate in the inner layers.

Type, *Lyttonia nobilis*, Waagen.

Distribution. Carboniferous.

Oldhamina, Waagen. 1883.

Shells highly concavo-convex.

Pedicle-valve subhemispherical; apex incurved, at maturity covered by a callosity, as in Bellerophon; attached by cementation in early growth. Hinge-line short and straight, not interrupted in the middle; below it lie well-developed teeth. Interior surface of the valve covered with diverging lateral ridges.

Brachial valve concave. Cardinal process inconspicuous, quadripartite at the summit; continuous with a median ridge extend-

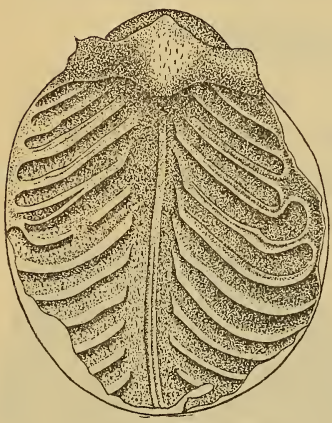


Fig. 657.

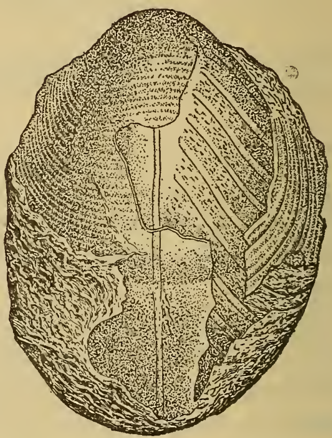


Fig. 658.

Oldhamina decipiens, de Koninck.

Fig. 657. The interior of a pedicle-valve; showing the median and lateral ridges.
Fig. 658. The exterior of a pedicle-valve with the shell partly exfoliated. (Waagen.)

ing the entire length of the valve. Internal surface covered with divergent grooves corresponding to the ridges of the opposite valve.

Exterior smooth or with numerous concentric lines of growth.

Type, *Oldhamina decipiens*, de Koninck (sp.).

Distribution. Carboniferous.

Eichwaldia, Billings. 1858.

(Plate 54, figs. 12-22.)

Shells subtriangular in outline, with biconvex valves, the pedicle-valve having a broad median sinus, and the brachial valve a corresponding median fold. The umbo of the pedicle-valve is acute and arched over the opposite valve, though not closely appressed against it. As far as has been ascertained, the umbonal space between the two valves is open, that is, there is no deltidium or pair of deltidial plates extending from the apex down-

Fig. 659.

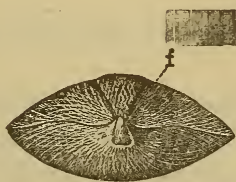


Fig. 660.

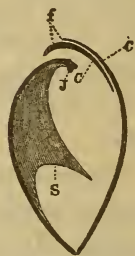


Fig. 661.

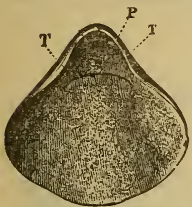


Fig. 662.

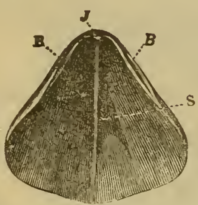


Fig. 663.

Fig. 664.

Fig. 665.

Eichwaldia reticulata, Hall.

Fig. 659. Dorsal view.
Fig. 660. Cardinal view.
Fig. 661. Longitudinal section of two valves.
Fig. 662. Interior of pedicle-valve.
Fig. 663. Interior of brachial valve.
Fig. 664. Vertical section of shell.
Fig. 665. Enlargement of the surface.

Notation: f, "bare spot" or foramen; p(c), deltidium or internal plate; c', umbonal surface of pedicle-valve; t, teeth; b, dental sockets; j, cardinal process; s, median septum of brachial valve.

ward; but there is a short triangular plate or diaphragm which begins at the apex of this valve and extends forward beyond the posterior edge of the brachial valve, and thus serves the purpose of the deltidium, though deeply depressed within the cavity of the pedicle-valve. This diaphragm is usually quite short and confined to the apical region, but it may extend for fully one-fifth the length of the valve, its anterior margin being free and its lateral margins adherent to the inner cardinal slopes. The cardinal line may be regarded as extending nearly to the lateral extremities of the valves; the articulating apparatus consisting of a pair of long marginal ridge-like teeth on the divergent cardinal slopes, fitting into narrow marginal grooves on the brachial valve. There is sometimes a trace of a median septum over the pallial region. In the brachial valve is a small callus, boss or cardinal process lying directly beneath the apex. Below this is a strong median septum, which increases in height anteriorly and rises to an acute, anteriorly directed apex at about two-thirds the length of the shell. In front of this point its anterior edge is concave, the septum disappearing not far within the margin of the valve.

No traces of muscular scars have been observed on either valve.

The external surface of the valves is covered by a coarse network of superficial cells, usually hexagonal, sometimes circular in outline. In all species and in early growth-stages there is a bare, smooth triangular area at the beak of the pedicle-valve, where this superficial ornament does not extend.

Type, *Eichwaldia subtrigonalis*, Billings.

Distribution. Lower Silurian — Lower Devonian.

Aulacorhynchus, Dittmar. 1871.

(Plate 54, figs. 23, 24.)

Shells short, transversely elongate or alate; extremities often rounded; hinge-line straight, usually making the greatest width of the shell. Valves very thin and fragile. Pedicle-valve slightly convex, with traces of a broad, obscure median sinus; brachial valve flat. Surface covered with numerous regular and continuous, concentric rounded folds or ridges which are separated by furrows of equal width.

In the pedicle-valve the character of the articulating processes has not been fully ascertained. There appears, however, to have been no cardinal area, and but exceedingly small teeth, judging from the structure of the brachial valve. Just within the apex of the valve, which is closely appressed against the opposite one, begins a pair of divergent, elevated ridges, which extend for one-third, or even one-half the length of the shell, and inclose a thickened area or platform, which terminates abruptly in a transverse anterior margin. This platform is the seat of the adductor and divaricator muscles, and probably rests upon the bottom of the valve and is not vaulted.

In the brachial valve there is a prominent cardinal process from the base of which diverge two lateral ridge or socket walls, lying just within the hinge-line: behind them are linear depressions or dental sockets. There is also a low median ridge extending from the base of the cardinal process into the pallial region.

The substance of the shell shows a coarsely prismatic cellular structure, as in Porambonites and Eichwaldia. According to Barrois, this cellular lamina is not superficial but is covered by a thin epidermal layer.

Type, *Aulcoryhynchus Pachti*, Dittmar. Carboniferous limestone.

Distribution. Carboniferous.

Richthofenia, Kayser. 1881.

These peculiar fossils, which bear a striking external resemblance to certain operculated corals, and present some suggestive

Fig. 666.

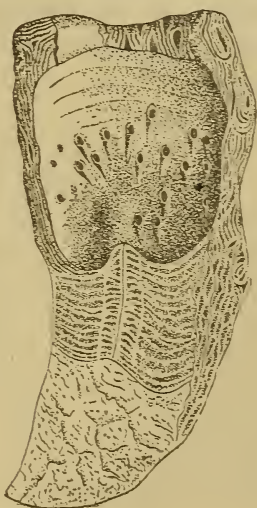


Fig. 667.

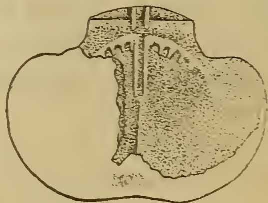


Fig. 668.

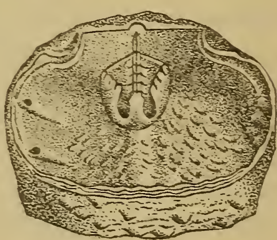


Fig. 669.

Richthofenia Lawrenciana, de Koninck.

Fig. 666. The exterior of the two valves in articulation.

Fig 667. Longitudinal section of the pedicle-valve; showing the interior cavity and the cellular shell substance.

Fig. 668. The interior of the pedicle-valve; showing the hinge-line and muscular scars.

Fig. 669. The interior of the brachial valve. (Waagen.)

similarities to the lamellibranchs Hippurites and Radiolites, have been carefully elaborated by Waagen, who arrives at the conclusion that they are of brachiopodous nature, the normal brachiopod characters being somewhat obscured by their mode of growth. From the accompanying figures, taken from Waagen's illustration of the genus, it appears that the valves when well preserved show a distinct hinge-line, faint articulating processes and muscular impressions, all more similar to the corresponding structure in the brachiopods than to anything occurring among the corals or Rudista. If this evidence of the brachiopodous nature of these fossils prove convincing, the remarkable development of the cellular testaceous tissue of the pedicle-valve, which produces the striking external resemblance to a coral, is certainly a no more extreme deviation from the brachiopod-type than are such bodies as Hippurites, Caprotina, Radiolites, etc., from the type of lamellibranchiate structure. The shells were evidently attached by solid fixation at the apex of the pedicle-valve, and this attachment strengthened by the epithecal rootlets extending downward from the walls of the valve, similar to those in Omphyma and other corals.

Type, *Richthofenia Sinensis*, Kayser.

Distribution. Carboniferous.

The Evolution and Classification of the Genera of the Brachiopoda.

In the foregoing pages, a consecutive account of the characters of the various genera of the Brachiopods has been given, without attempting to interrupt it with broader designations and groupings. In a work of this nature, such a consecutive narration of the genera is necessary, though wholly conventional and unnatural. The development of these animals throughout geologic time has not been along an undeviating line, but, on the contrary, is a series of departures at different periods in their history, from various comprehensive and prolific stocks. The courses of their existence can be expressed only by divergent and ramifying lines branching off here and there at rapid intervals during the vigor of the race, the off-shoots becoming more and more unlike as their growth continues, at times terminating abruptly as though unfavorable conditions had put a period to their existence, but usually in their prolonged existence and gradual decline resuming many of their early parental traits.

As a preliminary and general principle, it must first be observed that, in the development of any great race of organisms (always exemplified by those whose history is known for such an illimitable period as the Brachiopoda) the specialization of generic characters and the evolution of distinct generic stocks is carried on with much greater rapidity during their early existence than at any time in their later history. The primitive types embody the potentialities of all subsequent expressions which the race assumes.

It then becomes a question of elementary importance to ascertain these primitive generic types and to fix upon the radicle or root-stock from which all lines of evolution in this group have departed. With our present knowledge, it is believed possible to approximate these starting points in the history of the race with some degree of accuracy. Before, however, proceeding to this point, it is important to first consider the basis of a classification and the significance of certain structural features. We have come, in our study of these creatures, very close to the point where any grouping of genera into families, or of these into broader divisions, is so palpably a violation of nature's method as to make itself felt as an incumbrance. Hence the purpose of our treatment of these genera without such restrictions. Even among the generic groups there is so often an almost intangible transition from one to another that the employment of distinctive terms seems at times quite perfunctory; but with the increase of such difficulties the nearer our classification may be regarded as approaching the true method of development. To us the genus represents a structural unit, a point of departure; species, diverse expressions of the generic type; families, associations of genera representing the offspring of common parentage.

A classification is a broken and punctuated expression of organic affinities and interrelations, necessary to an easy treatment of any group of organisms, capable of expressing many truths in regard to the development of a race, but even in its most perfect state an index and confession of faulty knowledge.

In the earlier classifications of the Brachiopoda a high value has been ascribed to the disposition of the muscular scars upon the inner surfaces of the valves, the form of the genito-vascular sinuses and the configuration and degree of calcification of the brachia. To the last of these must still be ascribed a high degree of significance notwithstanding the fact that in the individual this calcification is a progressive process, increasing in extent from infancy to maturity. The plan of the muscular and vascular anatomy is, however, among the Articulate Brachiopods, but slightly modified through their history and in all their variations, but in the Inarticulate division we find it to be susceptible of a more varied expression.

But it is the variation of form, position and mode of enclosure of the pedicle-passage that affords the most satisfactory index of lines of progress and development. We have already briefly referred to, and described the principal modifications of these parts, but a restatement of these structural details is essential to our purposes.

In the chapter upon the "Development of the Shell" it has been shown that the *deltidium* and *deltidial plates*, though similar in function, are profoundly distinct both in origin and structure. The former is primitive and fundamental, the latter wholly secondary; a replacement of, but never a derivative from the former. They may resemble each other, as the so-called *pseudodeltidium* of CYRTINA is externally like the true deltidium of CLITAMBONITES, STROPHOMENA and RAFINESQUINA, but this is purely a superficial similarity. The pseudodeltidium consists, in its early condition, of discrete deltidial plates and in its mature state it expresses simply a firm coalescence of those plates. The term pseudodeltidium is a convenient one to employ for this peculiar phase of the deltidial plates; but we have proposed to distinguish the latter generally by the use of the term *deltarium* in application to the parts as a whole, whether coalesced (CYRTINA, NUCLEOSPIRA, RETZIA, etc.), or discrete, and *deltaria* in referring to the component plates. The reader is again referred to the chapter already cited for the full explanation of the differences in the deltidium and deltarium as worked out by BEECHER, in which it is demonstrated that the former is, in a certain sense, a *third valve*, not forming on the mantle lobes of the young as do the true valves, but upon the body of the embryo, enclosing the cardinal space between the latter. This solid, continuous, never divided plate or pedicle-sheath remains throughout all growth-stages in a large division of the Articulate genera mostly of early age, while in a coextensive group predominating throughout the later history of the class, this primitive structure is resorbed at an early stage of growth, and the enclosure of the pedicle effected by the formation of discrete secondary plates which originate from the mantle lobes and not from the body of the shell.

The term *spondylium* has been applied to the spoon-shaped plate which frequently occurs in the pedicle-valve of many of the Articulates (PENTAMERUS, CLITAMBONITES). A plate of similar character appearing in the brachial valve of the same groups of genera has been referred to under the same name, but it is found that these plates in the different valves are similar neither in origin or function; hence that of the brachial valve is now distinguished by the term *cruralium*. In the Inarticulate Brachiopods there are internal structures which seem to have served similar functions to the spondylium and cruralium of the Articulates. These occur in the genera Lingulasma, Trimerella, Dinobolus, and all the genera constituting the group termed by Davidson and King, the *Trimerellidæ*; and have been known as the *platforms.* Though all these structures have manifestly subserved the same purpose to the animal their origin is due to unlike causes though their growth was aided by similar conditions; hence they are not strictly homologous parts.

The *spondylium* is an area of muscular implantation. It is derived from the convergence and coalescence of the dental lamellæ and forms a receptacle primarily for the proximal portion of the pedicle and for the capsular or pedicle-muscles and eventually for all the muscles attached to the valve. For the inception of the platform on the pedicle-valve of the Trimerellids it is not so easy to assign an explanation, but its beginning once made, there seems no reason to doubt that the increase in size and prominence both of platform and spondylium has been greatly aided by the crowding of the essential organs of the animal about and beneath these muscular plates (see pp. 193, 194).

Considering the spondylium in its elementary condition where, as in Orthis, it is represented only by the convergent dental plates uniting with, or resting upon the bottom of the valve, enclosing only the base of the pedicle and its muscles, it becomes evident that the plate is actually but a modification of the original pedicle-sheath. It is the inner moiety of this sheath surrounding the pedicle, which has become involved in or enclosed by the growth of the pedicle-valve, and further modified by the development of articulating processes where it comes in contact with the brachial valve. It may, therefore, be inferred that wherever the spondylium is present, whether in the incipient condition or in the more advanced stage of development in which it supports all the muscles of the valve, it is or has, at some period of growth, been accompanied by the external portion of the sheath which is termed the deltidium. Thus the spondylium appears to be but the complement of the deltidium, and that the two were together included in the original or primitive deltidial plate formed upon the body of the embryo (prodeltidium).

The transverse plate or *platform* in the *brachial* valve of the Inarticulates is evidently homologous in origin and function with that of the pedicle-valve in the same group. On the other hand, the spoon-shaped process or *cruralium* in the brachial valve of the Articulates (Pentamerus, etc.), is a totally different structure from the spondylium, similar in function but of more fugitive valve. It has originated from the convergence and union of the crural plates, and it may, like the spondylium, rest upon the inner surface of the valve or be supported by a median septum.

The *cardinal area* is a feature of which we find a trace spasmodically among the Inarticulates, and, in the Articulates, is more generally developed in the deltidium-bearing genera, though it may be said that in this group also it is very irregular in its appearance. The genus Spirifer furnishes a striking instance of its persistence in the deltarium-bearing shells. It is probable that the existence of this area has little fundamental connexion with the condition of the pedicle-coverings. It is a very palpable fact that there is a much more intimate relation between this area and the general form of the shell; thus in the elongate shells like the terebratuloids, meristoids, retzioids and the pentameroids for the most part, there is no such area present. Where the form of the shell is more generally transverse as among the *Orthidæ*, in Strophomena, Clitambonites, Derbya, Spirifer, etc., the area is highly developed.

It has been suggested that this area may have originated in an obstruction to the peripheral growth of the valves upon their posterior margins, and would, therefore, be greatest in shells whose pedicle was short and necessitated a close attachment (see pp. 155, 163).

In this presentation of the characters of the generic groups, the genus Lingula has been taken as a starting point, more for the reason that it is a widely distributed and well-known type than because we have any reason to regard it as primitive.

The nearest approach to the radicle of the entire class is expressed by the genus Paterina, Beecher (p. 247), which bears at maturity the form and structure of the primitive shell or protegulum. It is orbicular in form, with a straight or arcuate hinge line and no cardinal area. The pedicle-opening is a broad triangular fissure, the valves being in contact behind only at and near the cardinal angles. Though this shell is from the Lower Cambrian faunas there are other brachiopods of obolelloid type that are quite as ancient; still Paterina exemplifies the source from which the development of more complicated forms has proceeded.

From this simplest of all known (and it might be fair to say, all possible) brachiopods, the development and specialization of generic characters proceeded in various directions. The orbicular form and preponderating chitinous shell-substance form essential traits of a considerable group of primeval genera represented by Obolus, Obolella, Elkania, etc., in which, however, decided progress is evinced in the rapid specialization of the muscular apparatus as well as in the restriction of the pedicle-passage to a narrow slit. Some closely allied forms with highly chitinous shell and obolelloid * muscular scars present an elongate rather than subcircular outline, and in this respect indicate a departure toward the characteristic linguloid exterior. This is first shown by the Cambrian and early Silurian genera Lingulella, Lingulops and Leptobolus.

The true Lingula, with its highly complicated muscular apparatus, appears to have become established and static some time after the opening of the Silurian (Trenton fauna) and we have no reason for believing that the type of structure fixed at that remote period differs essentially from the typical Lingulas of existing seas. It is not that offshoots and modifications were not given off, especially during the early periods of its existence, but such lateral departures were short-lived and the old firmly established generic type, resistant to variation in physical surroundings or adapted to the whole vicissitude of marine conditions, has perpetuated itself without modification as far as indicated by the structure of the shell.

Glossina, Dignomia, Barroisella and Tomasina, which represent early deviations from Lingula during the Silurian and Devonian periods, embody no substantial variations, though the last two demonstrate a gradual assumption of articulating processes.

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* Obolella is a more elementary type than Obolus, as is strongly evinced by the character of the muscular scars. In Obolus the latter are complicated and approach those of Lingula.

The purely conventional value of family designations could not be more forcibly illustrated than among the groups now under consideration, and as shown by the following facts: Among the Obolidæ there is, in a certain direction, a tendency manifested toward the formation of a thickened muscular platform, a structure to which we have already referred as being most highly developed in the trimerellids (Trimerella, Dinobolus, etc.). This is seen in the Cambrian genus Elkania, where these platforms are solid muscular thickenings of the shell, and their development is more highly advanced in Lakhmina, also of Cambrian age, in which the platforms are vaulted or excavated beneath. Dinobolus, which makes its appearance in the early faunas of the Silurian (Black River limestone), is a large shell of oboloid exterior and having these platforms well developed, sometimes solid, but often excavated. This genus continues its existence or rather, in accordance with our knowledge, reappears after a long interval, in the later faunas of the Upper Silurian in a fuller manifestation and in association with other platform-bearing genera, Trimerella, Monomerella, Dinobolus.

Among the Lingulidæ a similar tendency to the formation of these platforms manifests itself, though at a later period than in the oboloids. The elementary condition of development is expressed in Lingulops, and in a more advanced stage in Lingulasma, of the middle Silurian. In Trimerella, Monomerella and Rhinobolus of the later Silurian the linguloid form of the shell is retained and the highest stage of platform development attained. These shells have been closely studied; our knowledge of them is fairly complete, sufficient to justify us in the conclusion that in the *Trimerellidæ* (of Davidson and King; a very natural group, including Trimerella, Monomerella, Rhinobolus and Dinobolus, to which we should add Lingulops and Lingulasma), the derivation of the platform has been along two distinct and convergent phyletic lines, one departing from the oboloids, the other from the linguloids. The line of the platform bearing Inarticulates ends abruptly and finally with the close of the Silurian. The tendency to produce these platforms, which was then common to the oboloids and linguloids, and hence a heritage from common ancestry fails to manifest itself in other lines of departure

Some of the accessory causes contributing to the production of the vaulted plates seem to have been efficient at various times throughout the history of the entire class, and we find them manifested in the Articulate Brachiopods by the marginal elevation of the muscular area in Douvillina and Leptæna; they probably also served to render more complete the isolation and perfection of the spondylium, but the true platform does not again appear. (For suggestions as to the organic causes of such elevations see p. 194.) With the knowledge of so many transition genera between the oboloids and linguloids and trimerellids, it is a pure convention to accord recognition to the families *Obolidæ, Lingulidæ* and *Trimerellidæ.*

This entire group of genera is characterized by the presence of an unenclosed marginal pedicle. They compose the Mesocaulia or Lingulacea of Waagen (Atremata of Beecher).

The second main division of the Inarticulate genera is composed of those in which the pedicle-aperture, in immature stages or in primitive adult conditions takes the form of a marginal incision of the pedicle-valve, but becomes enclosed in the shell-substance in later stages of growth. To this group Waagen applied the term Diacaulia* or Discinacea (1883).

In the genus Orbiculoidea, early stages of the shell have the pedicle-passage or open triangular incision extending with widening margins from the apex of the pedicle-valve to the periphery. With advance of age this passage becomes contracted and normally closed at the posterior margin, and may be variously modified by the deposition of adventitious deposits about it. In the Cambrian genus Discinolepis the open slit is a mature character, and it also appears in several similar genera of later date, sometimes slightly modified, e. g., Trematis, Schizobolus, Œhlertella, in others quite primitive and unchanged, e. g., Schizocrania. These are all orbicular and highly chitinous shells; the line along which they have been derived departed at an early period from the radicle stock, apparently attained its diverse variations in Palæozoic time, and has been continued to the present in the most highly modified representatives of the

* This name was originally printed Daikaulia, probably a typographical error in the spelling of the first syllables.

group, Discina and Discinisca. All these forms are conveniently grouped under the family term *Discinidæ*.

In Acrotreta, Conotreta, Linnarssonia, Acrothele and Iphidea the pedicle-aperture is persistently located at the apex of the pedicle-valve. This group of genera is one of very early date, for the most part contemporaneous with Paterina, and the existing evidence would indicate that it was not directly ancestral to the line of Trematis–Orbiculoidea (*Discinidæ*). The incipient formation of an internal foraminal tube is seen in several of these genera (Acrotreta, Acrothele, Linnarssonia), and this feature attains its maximum in the true Siphonotreta of the Lower Silurian, where the foramen is still apical and the tube wholly internal. Hence Siphonotreta appears to be a normal termination of this line of descent. Schizambon, in the comprehensive meaning of the term ascribed to it in this work, has the pedicle-passage superficial, and in such shells as *Schizambon fissus*, Kutorga, and var. *Canadensis*, Ami, the condition of this passage is perfectly analogous to that of Siphonotreta, the entire difference being in the enclosure of the latter. In Schizambon the fibers of the pedicle, extending through the foramen near the middle of the pedicle-valve, were directed toward the apex of that valve, and along the concave floor of the external pedicle-groove. The inner aperture of the pedicle-tube in Siphonotreta, corresponds to the "foramen" of Schizambon, and the outer aperture, or true foramen, of the former to the grooved umbo of the pedicle-valve in the latter. Hence in Schizambon, thus considered, there is no evidence of a progress of the external aperture, or true foramen, anteriorly beyond the apex of the pedicle-valve. These two genera are but slight departures from the same type of structure, but it would appear that this deviation took place during primordial times, as the typical Schizambon (*S. typicalis*, Walcott) is a primordial fossil. The genus, Trematobolus, Matthew (*T. insignis*, Matthew, type), appears to be another primordial representative of this structure, with the tubular enclosure of the pedicle more highly developed. Thus all these genera, from Acrothele to Schizambon and Siphonotreta, possess an apical foramen, and the development both of the internal tube and the corresponding external groove has been a gradual one. They represent termini of slightly divergent series, consequently they may all be safely included under the old family designation introduced by Kutorga in 1848, *Siphonotretidæ.*

Crania and its allies (Craniella, Pseudocrania, Pholidops) constitute a group in which, thus far, there is no satisfactory evidence of the existence of the pedicle, and we are left to the assumption that this organ became atrophied at a very early growth-stage. The study of recent Cranias has not yet determined this point, but will probably ultimately accomplish this end. At whatever stage of growth the pedicle was lost, we may infer that its disappearance was directly followed, in Crania, and generally in Craniella, by a solid fixation of the animal by the substance of one of the valves. In Pholidops there was no such cementation, but at a correspondingly early stage the shell became wholly independent. All these shells with central or subcentral beaks have an external resemblance to Orbiculoidea; the formation of the secondary growth of the valves behind the apices or position of the protoconch, is a further substantial agreement with the Diacaulia as contrasted with the abbreviated posterior peripheral shell-growth in the Mesocaulia (Lingula, Obolus). It is nevertheless to be observed that no trace is found on mature or immature shells, of a former pedicle-slit, incision or perforation, and it would be difficult to comprehend in what manner such an essential modification of the shell could be wholly concealed by later growth.* Were the pedicle marginal in primitive growth-stages, and subsequently atrophied, the obliteration of the marginal opening by later resorption and growth would be a readily intelligible process. There is, hence, in this default of evidence, a good reason to doubt the close affinities of Crania and Pholidops to the Diacaulia. Present knowledge would seem to indicate that they were primarily of the type of the Mesocaulia, and that their resemblance to the Diacaulia is wholly of secondary growth.† Waagen's term for this group Gasteropegmata (or Craniacea), may therefore prove to be equivalent to each of these other two divisions.

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* Quite early conditions of *Crania siluriana* and *Craniella Hamiltoniæ*, from 1.5 to .5 mm. in diameter, are fully cemented. Examples of *Pholidops Hamiltoniæ*, not above .5 mm. in diameter, give no indication of a pedicle-passage or surface characters not present in the adult.

† Some species of Pholidops (*P. arenaria*, *P. linguloides*) have a terminal submarginal apex; and their resemblance exteriorly to the oboloids is very striking. This is, however, no more than a resemblance, as they show, on the under side, the same mode of peripheral growth beneath the beak as the other forms of the genus in which the umbones are more nearly central.

The great gulf which has seemed to exist between the Inarticulate or Lyopomatous, and the Articulate or Arthropomatous divisions of the Class Brachiopoda; those without teeth, and those with teeth; those with a largely corneous shell, and those whose shell is essentially calcareous, is not yet fully spanned at many points.

These divisions were based upon the study of living brachiopods in which all the characteristic differences are pronounced and fixed. It is natural, however, to find among the early brachiopods, in which the adjustment of the organism to its conditions was highly sensitive, that the oscillation and specialization of characters has been very rapid. The development of articulating processes has already been noticed among the linguloids in Barroisella, Tomasina and Trimerella, among the oboloids in Spondylobolus, and among the siphonotretoids in Trematobolus. It is known that the shell of many inarticulates is almost wholly calcareous, as in the *Trimerellidæ*, and all of the Gasteropegmata. The alteration in the nature of the shell-substance from the protoconch or its exemplar, Paterina, which appears to be wholly or essentially corneous, to the typical articulate brachiopod, in which the corneous substance is reduced to a thin epidermal film, is a gradual process whose various stages are well understood. In Obolella, Elkania, and the early forms of Lingula, the deposition of calcareous salts in the shell was already advanced, these layers alternating with thinner layers of corneous substance. The gradual and eventual predominance of the calcareous shell-matter along both of these lines of development is seen in the ponderous Trimerellids of the later Silurian. The graduation of the corneous Paterina (*Kutorgina Labradorica*, var. *Swantonensis*) through *Kutorgina Labradorica*, and into the true calcareous Kutorginas (*K. cingulata*, *K. Whitfieldi*), is similar evidence. In *Kutorgina Latourensis*, Matthew described a minute tooth on either side of the pedicle-opening, and it has been stated that *K. cingulata* shows faint traces of articulating processes at or near the extremities of the cardinal line. Such cases indicate a direct transgression in the texture and composition of the shell from the most primitive inarticulate type to the articulate. In this feature only, the connection between the two divisions of the class is no closer or more clearly manifested than in the instances mentioned, but it has been shown that *Kutorgina cingulata* may retain a pedicle-covering or external sheath, in fact a true deltidium bearing an apical perforation, like that in Clitambonites. The same character is highly developed or fully retained at maturity in Iphidea. This is evidence of the highest moment, and conclusively shows the line along which the clitambonitoids and strophomenoids have been derived. It is an immediate departure from the primitive type of the brachiopod into the articulate subtype.

Passage from the inarticulate to the articulate plan of structure was thus effected at a very early period; indeed, almost at the outset of the history of the group. The continuance of the two types has since been that of diverging series, constantly widening the structural gap between them. We have no irrefragible evidence that this chasm has been bridged at any other point than near its source; the inclinations from the one type toward the other, shown in the articulating processes of Barroisella, Tomasina, etc., represent uncompleted accessory lines of development, which were abruptly terminated without accomplishing the full transitions. Such forms have left no descendants, so far as known.

The most elementary structure, then, observable, among the Articulate Brachiopods is the combination of the deltidium with a distinct pedicle-cavity, whose anterior margins are not free, and whose lateral walls or dental lamellæ are not highly developed; these features being accompanied by gently and unequally biconvex valves, well-defined cardinal areas and elongate hinge-line; producing, in effect, a generally orthoid expression both of interior and exterior. This is the condition of Billingsella of the Cambrian, *Orthis loricula* and *O. deflecta* of the Trenton group, and *O? laurentina* of the Hudson River fauna, and it is continued without essential modification, except in the gradual contraction of the pedicle-cavity and deltidium, into Strophomena of the Silurian, its allies and successors, Orthothetes of the Devonian, and Derbya of the Carboniferous, Hipparionyx, Triplecia, Streptorhynchus, etc., into Leptæna, Rafinesquina, Stropheodonta, Plectambonites, Chonetes and Productus.

The tendency to contract the pedicle-cavity and deltidium presents its extreme manifestation in the Devonian forms of

Stropheodonta, Strophonella and Leptostrophia, where it has become almost, and sometimes quite obliterated, and the entire pedicle and umbonal cavity filled with testaceous secretions. Such filling can occur only in a discarded and useless space, after the pedicle has ceased to be functional. A morphological consideration of much importance presents itself here, as well as in many other groups of genera where the shells attain great size. The evidence is very direct from the study of the structural features as given above, that the entire muscular system on the ventral side of the body is, in primitive forms, inserted upon the base of the pedicle-cavity. This is apparent from a study of such a shell as *Orthis callactis*, where it is perfectly clear that no muscular bands were attached to the pedicle-valve outside the limits of this strong and condensed posterior area, which is but a sessile spondylium. The contraction of this pedicle-cavity is accompanied by (whether in relation of cause to effect may not be stated) a diffusion of the area of muscular attachment, and when the shells are large, as in Strophomena, Rafinesquina, Stropheodonta, Orthothetes, Derbya, etc., the necessity for powerful muscles or some similar cause magnifies this expansion of the muscular area until the original contents of the pedicle-cavity may be represented by enormous muscles whose scars extend almost to the anterior margin of the valve, as in Hipparionyx and Rhipidomella.

In this great group of genera there are two types of contour, one, as in Leptæna, being normally convexo-concave, that is, with the pedicle-valve convex and the brachial valve parallel to it and concave; the other, as in Strophomena, having this contour reversed, the pedicle-valve at first convex, but subsequently and through all later growth-stages concave, while the brachial valve becomes correspondingly convex. In both cases, as in other brachiopods, the primitive and post-embryonic valves are both convex. The peculiar reversal of contour, which is never more extremely manifested than in this group, but nevertheless occurs in other genera, such as Atrypa, many Rhynchonellas, etc., is a purely secondary condition. Its causes have not been fully investigated, but an unequal peripheral growth of the two valves seems to be a sufficient explanation of its existence. As either the presence or absence of this reversal is a normal secondary condition, it is not possible to give it great weight in a broader grouping of the genera, for we find that Strophonella is but a reversed Stropheodonta, passing through similar phases; Amphistrophia is a reversed Brachyprion, both existing in faunas of the same age, and Strophomena is a reversed Rafinesquina, both similarly coexistent.

With this presentation of the subject it seems neither necessary nor desirable to propose any broad division of this group of genera. In 1846 King proposed to embrace Strophomena and its allies in the family *Strophomenidæ*. The large number of generic values allied to Strophomena, which have been determined since that date, make this comprehensive family divisible *ad libitum, sed non in majorem Dei gloriam.*

The calcareous fixation of the pedicle-valve to extraneous bodies after the closure of the pedicle-passage and atrophy of the pedicle itself, is repeatedly manifested by these shells. This, as already shown, is a pre-adult condition in Orthothetes, Derbya and Streptorhynchus, the shell becoming wholly free before full growth was attained; but in Leptænisca and Davidsonia the attachment was maintained throughout the later existence of the shell.

The impressions left by the spiral arms upon the interior of the valves in Davidsonia and Leptænisca, and also observed by Davidson in a specimen of *Rafinesquina Jukesi*, show a complete correspondence in the direction and curvature of the coils, and we are left to infer that other members of the *Strophomenidæ* were in agreement with this structure, and hence that the arms in their uncalcified condition approached nearer the calcified spirals of *Koninckinidæ* (Cœlospira, Koninckinia, etc.) than to those of any other group.

The condition of the pedicle-passage possessed by these shells is maintained by Chonetes and Productus, without great modification in other respects. Chonetes possesses a marginal row of strong cardinal spines or tubes communicating with the internal cavity of the valves. Yet we are acquainted with forms (*e. g.*, *Anoplia nucleata*) in which these spine-tubes do not manifest themselves externally. Productus is normally covered with spines on one or both valves, but there are some species which possess none. The cardinal area, deltidium and teeth, which are retained in Chonetes, Productella, Strophalosia and Aulosteges, become wholly obliterated in the direct line of productoid development. In all these forms the "reniform impressions" retained on the inner surface of the brachial valve are evidence of fleshy brachia possessing a similar curvature to those of the *Strophomenidæ*.

This group of genera has long been designated by the family name *Productidæ*, introduced by Gray in 1840, though, in correlating the various divisions of Waagen's group, Aphaneropegmata, there would be excellent reason for considering the chonetids and productids components of a subfamily inferior in value to the *Strophomenidæ* and quantivalent to the divisions *Orthothetinæ*, Waagen, 1884, and *Rafinesquininæ*, Schuchert (*emendatus*), 1893.

Returning to the point of departure, we shall find that in the genus, Orthis, which in its broadest significance is tantamount to the family *Orthidæ*, Woodward, 1852, since the elimination of several heterogenous branches, the deltidium was resorbed at an early stage of growth, leaving the delthyrium a wide, uncovered aperture during all the later stages of existence. The pedicle in this group of shells was undoubtedly large and vigorously functional throughout all mature conditions, as it is very rarely that any secretions of calcareous matter are found in the apex of the delthyrium, such as are frequently observed in mature and senile conditions of Spirifer. The sharp delimitation of the pedicle-cavity containing all the muscular scars of the pedicle-valve, which occurs in the earlier forms (those of Orthis in its restricted meaning, such as *O. callactis*, *O. costalis*, etc.) is maintained in all the numerous subdivisions of the genus, with the exception of Rhipidomella in which there is a great expansion of the muscular scars, similar to that in the *Strophomenidæ* and to which reference has just been made. Otherwise the sessile condition of the spondylium is not modified throughout the entire history of this group.

The elevation of the spondylioid plate, or the base of the pedicle-cavity, into a true spondylium is a phenomenon of equally early age to the two conditions already discussed. It appears in a highly-developed state in conjunction with the unmodified deltidium, first in Protorthis, of the Cambrian, then in Polytœchia, Syntrophia, Clitambonites and Scenidium of the early and later Silurian and of the Devonian.

A parallel line of development is exhibited by spondylium-bearing forms in which the deltidium disappeared at a very early period, and the shells possess a trihedral, generally coarsely plicated and decidedly rhynchonelloid exterior. It seems highly probable that this line was differentiated in the early Cambrian, as indications of this structure are observable in some primordial species, as *Camarella? minor*, Walcott, and *Stricklandinia? Balcletchensis*, Davidson; in the Silurian it is represented by Camarella and Parastrophia, by the more rotund and more finely plicate shells, Anastrophia, Porambonites, Lycophoria and Nœtlingia. The last-named genera are not homogeneous with the others in the phases of development which they represent, all of them retaining the cardinal areas more or less distinctly, while Lycophoria and Nœtlingia also possess a cardinal process in the brachial valve. The presence of the cardinal area in such early structures must be regarded as a retention, rather than a resumption of a primitive character.

Whatever may be the oscillation in form and the variation in secondary characters presented by Camarella, Parastrophia and their allies, present evidence indicates that they must be regarded as the genetic precursors, as they are the secular precedents of the great group of true pentameroids (Pentamerus, Capellinia, Conchidium, Barrandella, Sieberella, Pentamerella, Gypidula, Stricklandinia, Amphigenia); and, indeed the last of these pentameroids, Camarophoria, of the Carboniferous and Permian faunas, is an exemplification of, and in fact a return to the rhynchonelloid exterior and the camarellid aspect, with the addition of deltaria in the delthyrium.

While considering in detail the pentameroid genera mentioned above, it has been shown that in certain of them, as Pentamerus and Conchidium, a true deltidium is often retained, though it is a fragile structure rendered concave by the arched growth of the umbones of the valves, and is generally absent. In others, as Gypidula and Pentamerella, there are occasionally evidences of lateral, erect or convex growths upon the margins of the delthyrium, which may be interpreted either as remnants of a resorbed convex deltidium, or as highly accelerated secondary deltaria. Every now and then specimens will show a clearly-developed cardinal area; always in Stricklandinia, frequently and normally in Gypidula, rarely in Pentamerella. Stricklandinia possesses so straight and long a hinge, so sharply defined an area and so short a spondylium, that it is more natural to regard this genus as the accompaniment, rather than the close organic kin of the other pentameroids, deriving its differentials directly from those long and straight hinged shells of the early Silurian, which constitute the genus Syntrophia.

It will not now appear a matter of inexplicable aberrancy that the spondylium presents itself in the great secondary groups comprising the rhynchonellids, and those shells with calcified brachidia. Hence we meet with it in Cyrtina and Camarospira in a highly-developed state, and in Camarotœchia in a less advanced condition, while Amphigenia presents the remarkable combination of a spondylium coexistent with a shell of completely rensselæroid aspect (that is, in respect to form, contour, muscular markings and articulating apparatus) and with rhynchonelloid brachial supports.

Attention has already been directed to the fact that some of the *Rhynchonellidæ*, early in their history, occasionally retain a well-defined cardinal area and that, in default of other evidence, the presence of this character may be regarded as indicative of the common origin of Orthis, the *Strophomenidæ*, and the Rhynchonellas. The earliest phyletic stages of the rhynchonellids must have been highly accelerated, for there is no evidence of any form which has shown the slightest trace of deltidium. Nevertheless the early forms of the Silurian, such as Orthorhynchula and Protorhyncha, rarely show any indication of deltaria at maturity, but the delthryium, in its final stage, is unobstructed and simple, as in young conditions of later rhynchonellids in which the deltaria fully develop. We may look upon the *Rhynchonellidæ* as a family whose characters became established very early and have been perpetuated up to the present without wide departure, at any time, from the early derived type.

In the study of the multifold variations of the articulates bearing calcified spiral brachial supports, the Helicopegmata of Waagen (1883), the conclusion has enforced itself that the degree of solidification of the brachia in this group is to be regarded as an index of differentiation. To illustrate: There is no evidence for assuming that the single revolution made by the spiral in Protozyga and Hallina represents an incomplete spiculation of the brachia, or that the spiniform and discrete jugal processes in Spirifer, persisting throughout the genus, do not fully exemplify the adult condition of the jugum (=loop) in these shells. The mode of spiculation of the brachia in such of the living terebratuloids, in which the solidification is direct or without complicated metamorphoses, is on the whole confirmatory of this inference; but as there is no living representative of the spire-bearing forms evidence in regard to the mode and degree of spiculation in this group to be derived from the existing loop-bearing shells, in which the brachial supports pass through highly complicated metamorphoses, is not altogether germane. In such intricate structures as the brachidia of Athyris, Kayseria, Koninckina, etc., there can be little doubt that the calcified apparatus represents the full extent of the fleshy brachia simply because, if for no other reason, the further expansion of the brachial lamellæ would not be possible for want of space. Moreover, in the spiculation of the spirals in all these old shells there have been no changes of form in later growth except those proceeding from the normal process of resorption and deposition necessary for increase in size and length. The reason why the spiculation should be complete in the spire-bearing forms, while in the Ancylobrachia or the terebratuloids it does not extend beyond the loop and the lateral extensions of the brachia, but in the *Rhynchonellidæ* affects only the crura, and in the *Strophomenidæ* does not occur, even in the most elementary condition, is for future investigations to ascertain.

The form of the paired spirals varies but little except under the necessity of conforming to the interior cavity of the valves. Their inclination and direction is a feature of much significance when considered with reference to the development of the entire shell. It is, however, the loop, or to employ a term more appropriate in view of the homologies of the spire-bearing and loop-bearing shells, the *jugum*, which is subject to the most frequent variations in form, and which serves as the generic index. When the spirals are directed outward toward the lateral margins of the valves, the jugum seems to be much more variable than in shells where the spirals are introverted or take some intermediate position. In the latter there is a much greater variation in the position of the loop upon the primary lamellæ than occurs in the former.

The earliest spire-bearing shells yet discovered are the simplest, in the structure of the brachidium. Hallina, Protozyga, Cyclospira of the Lower Silurian possess brachidia which make a little less than one or two volutions of the calcified lamellæ, with a slight inclination toward each other, and to the median axis of the shell. Zygospira and Glassia, the contemporaries and successors of these primitive structures, show progressed conditions of the same form of brachidium. In these genera, however, there is a slight deviation in the vertical axes of the spirals from the transverse axis of the shell, the apices being inclined somewhat toward the brachial valve, and this tendency to lateral evolution in the spiral cones is carried to its extreme in the genus Alrypa where the multispiral cones of the fully matured forms of the Devonian, may sometimes have their axes nearly parallel. This is the termination of all revolution of the cones, a change through an arc of less than 90°, probably due in a large degree to alterations in the form of the internal cavity of the valves; and the fact that this revolution here ceases, strictly delimits the group of forms bearing spirals of this type (*Atrypidæ*).

It is well to emphasize the fact, lest misconceptions already set on foot should become prevalent, that no wider revolution of the spiral cones exists. It is true that there is a difference of 18° in the position of the axes of the spiral cones in Cyclospira and Spirifer, but the spirals have never, by gradual changes, revolved from their inverted position in the former to their everted position in the latter. Such a process might have been possible, but had it actually occurred the forms resulting would have been totally different in structure from any now known. Instead of having the primary lamellæ and jugum on the dorsal side as in all shells with everted spirals, these parts would lie on the ventral side of the shell. It must hence be inferred that the *Spiriferidæ,* the *Athyridæ,* the *Meristidæ,* and all genera with everted brachidia are related to the *Atrypidæ* only through their early ancestral forms.

The Lower Silurian faunas have furnished no evidence of species with everted spirals, and this hiatus in our knowledge forbids any satisfactory deductions as to the source or derivation of these forms. It is true in a general sense that the eversion of the spirals is accompanied by a convexity of both valves, just as the inverted spirals of the *Atrypidæ* are associated with valves of notably unequal depth. Still, among the latter, Glassia possesses biconvex valves, while of the former the group composed of Cœlospira, Anoplotheca, Koninckina and Amphiclina is characterized by convexo-plane or convexo-concave valves. In this group also the apices of the spirals are not directed toward the lateral commissures of the valves, but toward the lateral slopes of the pedicle-valve, such a form and direction being a necessary outcome of the contracted interior space. From present evidence it would seem probable that among the early Silurian species will be found some form whose spiral ribbon deviates outwardly from the vertical plane to the same degree as it inclines inwardly in Cyclospira and Protozyga. Indeed, in *Cyclospira bisulcata* itself, the spiral sometimes lies so nearly in the vertical plane that the inward inclination of the apices is not always positive. Only some such form of the earliest faunas could have been the progenitor of the everted spirals.

In the *Atrypidæ* possibilities of variation in the form of the jugum were much restricted; in the other groups of the spire bearers they were very great, and resulted in the production of a wonderful series of modifications whose relations it is not necessary to rehearse here. The extreme range of these modifications is seen in the simple termination of the jugum in Whitfieldella, Rhynchospira, etc.; the bifurcate extremity in Meristina, Eumetria and Retzia, these terminal branches in Kayseria, Diplospirella, etc., finally becoming coextensive with the lamellæ of the primary spirals and thus forming a second pair of spiral cones. This complication of the brachidium is effected only late in the history of the various groups producing them. Koninckina and Amphiclina are double-spiraled convexo-concave shells which are the post-palæozoic and final representatives of Anoplotheca and Cœlospira. Pexidella and Diplospirella, of the St. Cassian beds, are double-spiraled athyroids; Kayseria, of the middle Devonian, which is the only double-spiraled form known in the Palæozoic, appears to be an aberrant and accelerated representative of the stock which by more gradual development produced Retzia and Eumetria.

Only one large group of spire-bearing shells retains the cardinal area, namely, the *Spiriferidæ,* a family with everted spirals, one of the earliest to appear and the last to disappear. Its abundant representatives possess the longest of spirals and for the most part these are greatly extended transversely, held at arm's length, as it were, unsupported by a connecting jugum (except in the more sparsely represented genera Cyrtina and Spiriferina), but in spite of the delicacy of the structure, its apparent mechanical disadvantages in the absence of a continuous jugum, this type of structure has maintained its distinctive character and multiplied in a most remarkable manner.

The relations of the brachiopods with spiral brachidia, to the Ancylobrachia, or those shells commonly spoken of as the terebratuloids, has been a fruitful subject of discussion and given rise to investigations of great astuteness and merit. Reference has already been made to the facts established by Beecher and Schuchert from the development of the brachidium in Zygospira, which show that this atrypid passes through a growth-stage in which the brachidium has a simple terebratuloid form, similar to that in the mature condition of Dielasma; that the spirals are formed by the continued growth of the descending lamellæ of the loop beyond the point of their recurvature into the ascending lamellæ. What is thus true of Zygospira we must assume to have been true of the Helicopegmata generally, and the analogies thus established between them and the loop-bearing shells are these;— the entire loop in Dielasma, Cryptonella, etc., corresponds to that portion of the brachidium, in the spire-bearing forms, which lies behind the anterior basal edges of the jugum; the descending lamellæ of the former represent only the posterior portion of the primary lamellæ of the latter, while the ascending lamellæ and transverse connecting band of the Ancylobrachia are the equivalent of the jugum in the spire-bearers. The spirals, however, are a later development in the individual, and are hence undoubtedly a subsequent phyletic condition. Hence it is inferred that the spire-bearing forms have derived their brachidia from a primitive terebratuloid condition, and this derivation has been effected by growth with accompanying resorption. The progressive modification of the loop in the recent terebratellids by resorption of calcareous tissue in the growth of the individual, is a well-known fact which has invited the study of many investigators. In such forms this modification is extreme and is unquestionably complicated by the intimate connexion of the loop with the median septum of the brachial valve. Among the palæozoic genera there is, with the single exception of Tropidoleptus, no clear evidence that the median septum has shared in, or contributed to the growth-modifications of the brachial supports; nevertheless, the outcome and final result of this growth with modification in the most progressed forms of Terebratella and such palæozoic genera as Dielasma, Cryptonella, Harttina, etc., is the same.

Progressive modification of the brachial supports in both the Helicopegmata and palæozoic Ancylobrachia being now fully established, it is interesting to observe that the primitive condition of the loop, as in *Dielasma turgida*, is one of simple apposition of the two short brachial processes, at their expanded anterior extremities; having the expression of the mature loop in the genera Centronella, Rensselæria, Selenella, etc. A simple step further back would afford a condition in which the brachial processes with their expanded extremities are not as yet united but discrete as in the rhynchonellids. A more primitive condition than that in Centronella or the centronellid stage in Dielasma, could not be different from this. On the ground of these differences in the conditions of the brachidium and the phyletic stages corresponding thereto, it would seem fair to infer that of the rhynchonellids, the terebratuloids and the spire-bearers, the first is the primitive stock, and the spire-bearers legitimate derivatives of that stock, through the terebratuloids, or both of the latter derived along divergent lines from the rhychonellids. This conclusion, however coherent and consistent with the geological evidence, will be found to lack stability until the data are sufficient to establish the fact that the brachia themselves, and not alone their calcareous supports, have passed through corresponding phases of growth and derivation. This latter question must long be a matter of legitimate speculation, and in view of this fact few arguments of such a nature in this place will be permissible. The living representatives of Rhynchonella and Terebratula are animals in which a very considerable part of the brachia does not become sufficiently spiculized to form a continuous calcareous support. In *R.* (*Hemithyris*) *psittacea*, for example, the brachia are as highly developed in the form of coiled spiral arms as they could have been in most of the ancient spire-bearers, but their calcareous supports are only the short lamellæ known as the crural processes. All of the living Ancylobrachia which possess a long recurved loop like that of Cryptonella and Dielasma of the Palæozoic, have an unsupported median unpaired spiral arm, coiled in a direction which is the reverse of that prevailing among the spire-bearers. If, now, we are to interpret the condition of the brachia in the fossil rhynchonellids and terebratuloids from the adult condition of the brachia in their nearest living representatives, it becomes necessary to assume that on the one hand the palæozoic rhynchonellids possessed long coiled spiral arms, and, on the other, that Dielasma and its palæozoic allies and affines, when mature, were provided with the unpaired coiled arm of Terebratella. This assumption, in the first place, totally destroys the inference above made as to the primitive relation of the rhynchonellids to the Ancylobrachia and Helicopegmata; and secondly, would seem to necessitate a novel and unexpected interpretation of the brachial structure in all the spire-bearers. If Dielasma possessed the median arm, supported at its base by the transverse band of the loop, which corresponds to the jugum or the spire-bearers, then in the Dielasma stage of Zygospira and other spiriferous shells, where this stage was well defined, there must also have been a median coiled arm of some extent. This median arm, in living forms, is due, as shown by Beecher, to the necessity of finding room for the cilia or tentacles multiplying at the extremities of the brachia. The mere presence of the transverse band in Dielasma and the Dielasma-stage of Zygospira implies a similar extension of the brachia, and from the analogy, a median arm. The subsequent growth of the brachia in Zygospira, carrying the calcareous ribbon forward, beyond the bases of the loop and into lateral spiral cones, would not of itself afford sufficient reason for assuming that the growth of the brachia at their extremities, which produced the median arm, was necessarily discontinued, but rather that this median unpaired arm coexisted with the lateral paired spirals. This course of argument, though seemingly logical, appears to be be based on insufficient premises. The brachiopods with which we have to deal in the Palæozoic are essentially primitive structures, whether rhynchonellids, terebratuloids or spire-bearers. If the living Rhynchonella and Terebratella possess in their mature condition extensive free arms, it does not necessarily follow that their early palæozoic representatives were provided with similar uncalcified extensions; on the contrary, it would be much more reasonable and in accordance with our knowledge of natural laws to infer that in these early forms the adult condition of the brachia was more nearly that of immature conditions of these organs in their living representatives. There is a primitive condition of development in the Ancylobrachia in which the loop is coextensive with the brachia. There is reason to believe that such has been the relation of these parts in the primitive terebratuloids, as Centronella, Rensselæria, Cryptonella, Dielasma, etc.; in Tropidoleptus, which has been shown to represent a highly primitive phyletic condition of the *Terebratellidæ*; and, also in the earliest spire-bearers and rhynchonellids. Hence the conclusion above expressed as to the successive phyletic relations of the primitive rhynchonellids, terebratuloids and spire-bearers and based upon the relations and modifications in the form of their brachial supports, is fairly substantiated by the evidence drawn from other data.

The divergence from the ancestral rhynchonellid stock was very early and the differentiation undoubtedly consisted, to a large extent in rapid acceleration of growth in the brachia, and obstruction to the coextensive development of the fleshy arms and their supports.

Finally, it is desirable to again recall the intimate similarity between Rensselæria and the pentameroid genus Amphigenia; genera in which the essential distinction between the typical forms of each lies in the simple loop of the former and the long, expanded but still discrete crural processes of the latter. Attention has been directed to these similarities and differences, and it has also been pointed out that the spondylium in *Amphigenia elongata* is at times almost reproduced in specimens of *Rensselæria ovoides* where the dental lamellæ are highly developed.

TABLE OF CLASSIFICATION.

Class BRACHIPODA.

Paterina,* Beecher, 1891.

Sub-Class INARTICULATA, Huxley; LYOPOMATA, Owen.

Order Mesocaulia or Lingulacea, Waagen.

Family Obolidæ, King.

Obolus, von Eichwald, 1829.
Ungula, Pander, 1830.
Ungulites, Bronn, 1848.
Aulonotreta, Kutorga, 1848.
Acritis, Volborth, 1869.
Schmidtia, Volborth, 1869.
Mickwitzia, Schmidt, 1888.
Spondylobolus, McCoy, 1852.
Obolella, Billings, 1861.
Dicellomus, Hall, 1871.
Elkania, Ford, 1886.
Billingsia, Ford, 1886.
Botsfordia, Matthew, 1893.
Neobolus, Waagen, 1885.
Monobolina, Salter, 1865.

Family Lingulidæ, Gray.

Lingula, Bruguière, 1792.
Pharetra, Bolton, 1798.
Lingularius, Duméril, 1806.
Lingulella, Salter, 1866.
Lingulepis, Hall, 1863.
Leptobolus, Hall, 1871.
Glossina, Phillips, 1848.
Dignomia, Hall, 1871.
Barroisella, Hall, 1892.
Tomasina, Hall, 1892.

Family Trimerellidæ, Davidson and King.

Lakhmina, Œhlert, 1887.
Davidsonella, Waagen, 1885.
Lingulops, Hall, 1871.
Lingulasma, Ulrich, 1889.
Dinobolus, Hall, 1871.
Conradia, Hall, 1862.
Obolellina, Billings, 1871.
Monomerella, Billings, 1871.
Trimerella, Billings, 1862.
Rhinobolus, Hall, 1874.

* The genus Paterina, representing, according to our present knowledge, the fundamental stock or radicle of all the Brachiopods, might be embraced by some of the primitive families, both of the Inarticulata and the Articulata. By placing it, in this arrangement, outside both of the great sub-classes, it is the purpose to express the fact that the genus belongs as much to one as to the other, and that it is actually beyond the pale of both as it has not assumed the differential characters of either.

Order DIACAULIA or DISCINACEA, Waagen.

Family Discinidæ, Gray.

Discinolepis, Waagen, 1885.
Paterula, Barrande, 1879.
Schizobolus, Ulrich, 1886.
Trematis, Sharpe, 1847.
Schizocrania, Hall and Whitfield, 1875.
Œhlertella, Hall, 1892.
Lingulodiscina, Whitfield, 1890.
Orbiculoidea, d'Orbigny, 1847.
Schizotreta, Kutorga, 1848.
Lindstrœmella, Hall, 1892.
Rœmerella, Hall, 1892.

Family Siphonotretidæ, Kutorga, 1848.

Acrothele, Linnarsson, 1876.
Linnarssonia, Walcott, 1885.
Discinopsis, Matthew, 1892.
Acrotreta, Kutorga, 1848.
Conotreta, Walcott, 1889.
Mesotreta, Kutorga, 1848.
Schizambon, Walcott, 1884.
Siphonotreta, de Verneuil, 1845.
Orbicella, d'Orbigny, 1849.
Keyserlingia, Pander, 1861.
Helmersenia, Pander, 1861.

Order GASTEROPEGMATA or CRANIACEA, Waagen.

Family Craniidæ, King.

Crania, Retzius, 1781.
Numulus, Stobœus, 1732.
Ostracites, Beuth, 1776.
Criopus, Poli, 1791.
Criopoderma, Poli, 1791.
Orbicula, Cuvier, 1798.
Orbicularius, Duméril, 1806.
Craniolites, Schlotheim, 1820.
Choniopora, Schauroth, 1854.
Craniella, Œhlert, 1887.
Cardinocrania, Waagen, 1885.
Ancistrocrania, Dall, 1877.
Cranopsis, Dall, 1871.
Craniscus, Dall, 1871.
Pholidops, Hall, 1869.
Craniops, Hall, 1859.
Pseudocrania, McCoy, 1851.
Palæocrania, Quenstedt, 1871.

Sub-Class ARTICULATA, Huxley; or ARTHROPOMATA, Owen.

Order Protremata,* Beecher.

Family Kutorginidæ,† Schuchert.

Kutorgina, Billings, 1861.
Schizopholis, Waagen, 1885.
(?) Volborthia, von Möller, 1873.
Iphidea, Billings, 1872.

* In employing as the fundamental divisional distinction in the Articulata, the presence of the deltidium or the deltidial plates, the term Protremata covers better than any other those genera in which the primitive pedicle-covering is represented by either the deltidium, the spondylium, or both.

† Mr. Schuchert includes under this family term two genera, Kutorgina and Schizopholis, which have usually been regarded as belonging to the inarticulate sub-class. The reasons for the installation of these as the elementary family of the Articulata are given elsewhere.

Family Orthidæ, Woodward.

Orthis, Dalman, 1828.
Orthambonites, Pander, 1830.
Plectorthis, Hall, 1892.
Dinorthis, Hall, 1892.
Plæsiomys, Hall, 1892.
Herbertella, Hall, 1882.
Orthostrophia, Hall, 1883.
Platystrophia, King, 1850.
Heterorthis, Hall, 1892.
Bilobites, Linné, 1775.
Dicœlosia, King, 1850.
Dalmanella, Hall, 1892.
Rhipidomella, Œhlert, 1880.
Rhipidomys, Œhlert, 1887.
Schizophoria, King, 1850.
Orthotichia, Hall, 1892.
Enteletes, Fischer de Waldheim, 1830.
Syntrielasma, Meek, 1865.

Family Strophomenidæ, King.

Orthidium, Hall, 1892.
Strophomena, Rafinesque (de Blainville), 1825.
Orthothetes, Fischer de Waldheim, 1830.
Hipparionyx, Vanuxem, 1842.
Kayserella, Hall, 1892.
Derbya, Waagen, 1884.
Meekella, White and St. John, 1868.
Streptorhynchus, King, 1850.
Triplecia, Hall, 1848.
Dicraniscus, Meek, 1872.
Mimulus, Barrande, 1879.
Streptis, Davidson, 1881.

Family Leptænidæ.

Leptæna, Dalman, 1828.
Leptagonia, McCoy, 1844.
Rafinesquina, Hall, 1892.
Stropheodonta, Hall, 1852.
Brachyprion, Shaler, 1865.
Douvillina, Œhlert, 1887.
Leptostrophia, Hall, 1892.
Pholidostrophia, Hall, 1892.
Strophonella, Hall, 1879.
Amphistrophia, Hall, 1892.
Leptella, Hall, 1892.
Plectambonites, Pander, 1830.
Christiania, Hall, 1892.
Leptænisca, Beecher, 1890.
Davidsonia, Bouchard, 1847.
Cadomella, Munier-Chalmas, 1887.

Family Chonetidæ.

Chonetes, Fischer de Waldheim, 1837.
Anoplia, Hall, 1892.
Chonetella, Waagen, 1884.
Chonetina, Krotow, 1888.
Chonostrophia, Hall, 1892.
Chonopectus, Hall, 1892.

Family Productidæ, Gray.

Strophalosia, King, 1844.
Orthothrix, Geinitz, 1847.
Leptænalosia, King, 1845.
Daviesiella, Waagen, 1884.
Aulosteges, von Helmersen, 1847.
Productella, Hall, 1867.
Productus, Hall, 1867.
Marginifera, Waagen, 1884.
Proboscidella, Œhlert, 1887.
Etheridgina, Œhlert, 1887

Family Thecideidæ, Gray.

Thecidea, Defrance, 1882.
Lacazella, Munier-Chalmas, 1880.
Thecidiopsis, Munier-Chalmas, 1887.
Thecidella, Munier-Chalmas, 1887.
Eudesella, Munier-Chalmas, 1880.
Bactrynium, Emmrich, 1885.
Pterophloios, Gümbel, 1861.
Davidsonella, Munier-Chalmas, 1880.
Lyttonia, Waagen, 1883.
Oldhamina, Waagen, 1883.

Family Richthofenidæ, Waagen.

Richthofenia, Waagen, 1883.

Family Billingsellidæ, Schuchert.

Billingsella,* Hall, 1892.

Family Clitambonitidæ, N. H. Winchell and Schuchert.

Protorthis, Hall, 1892.
Polytœchia, Hall, 1892.
Clitambonites, Pander, 1830.
Pronites, Pander, 1830.
Gonambonites, Pander, 1830.
Hemipronites, Pander, 1830.
Orthisina, d'Orbigny, 1847.
Scenidium, Hall, 1860.
Mystrophora, Kayser, 1871.

Family Stricklandiniidæ.

Syntrophia, Hall, 1892.
Stricklandinia, Billings, 1859.

Family Camarellidæ.

Camarella, Billings, 1859.
Parastrophia, Hall, 1893.
Anastrophia, Hall, 1879.
Brachymerus, Shaler, 1865.
(?) Branconia, Gagel, 1890.
Porambonites, Pander, 1830.
Isorhynchus, King, 1850.
Nœtlingia, Hall, 1892.
Lycophoria, Lahusen, 1885.
Camarophoria, King, 1846.
Camarophorella, Hall, 1893.

Family Pentameridæ.

Conchidium, Linné, 1753.
Gypidia, Dalman, 1828.
Antirhynchonella, Quenstedt, 1871.
Zdimir, Barrande, 1879.
Pentamerus, Sowerby, 1813.
Barrandella, Hall, 1893.
Sieberella, Œhlert, 1887.
Capellinia, Hall, 1893.
Pentamerella, Hall, 1867.
Gypidula, Hall, 1867.
Amphigenia, Hall, 1867.

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* The genus Billingsella presents, in correspondence with its early geological age, an elementary structural aspect indicating that it may have served as a point of departure for the Orthidæ and Strophomenidæ.

Order TELOTREMATA, Beecher.

Sub-Order Rostracea, Schuchert.

Family Rhynchonellidæ, Gray.

Protorhyncha, Hall, 1893.
Orthorhynchula, Hall, 1893.
Rhynchotrema, Hall, 1860.
Rhynchotreta, Hall, 1879.
Stenoschisma, Conrad, 1839.
Camarotœchia, Hall, 1893.
Liorhynchus, Hall, 1860.
Wilsonia (Quenstedt), Kayser, 1871.
Uncinulus, Bayle, 1878.
Uncinulina, Bayle, 1878.
Hypothyris (McCoy), King, 1850.
Pugnax, Hall. 1893.
Eatonia, Hall, 1857.
Cyclorhina, Hall, 1893.
Terebratuloidea, Waagen, 1883.
Rhynchopora, King, 1856.
Rhynchoporina, Œhlert, 1887.
Rhynchonella, Fischer de Waldheim, 1809.
Halorella, Bittner, 1890.
Austriella, Bittner, 1890.
Norella, Bittner, 1890.
Rhynchonellina, Gemellaro, 1871.
Dimerella, Zittel, 1870.
Cryptopora, Jeffreys, 1869.
Atretia, Jeffreys, 1870.
Neatretia, Œhlert, 1891.
Peregrinella, Œhlert, 1887.
Hemithyris, d'Orbigny.
Acanthothyris, d'Orbigny.

Sub-Order ANCYLOBRACHIA, Gray.

Family Centronellidæ, Waagen.

Rensselæria, Hall, 1859.
Beachia, Hall, 1893.
Newberria, Hall, 1891.
Centronella, Billings, 1859.
Oriskania, Hall, 1893.
Selenella, Hall, 1893.
Romingerina, Hall, 1893.
Juvavella, Bittner, 1890.
Nucleatula, Bittner, 1890.
Dinarella, Bittner, 1892.
Trigeria, Bayle, 1875.
(?) Notothyris, Waagen, 1882.
Scaphiocœlia, Whitfield, 1891.

Family Terebratulidæ, Dall.

Cryptonella, Hall, 1861.
Eunella, Hall, 1893.
Harttina, Hall, 1893.
Megalanteris, Suess, 1855.
(?) Enantiosphen, Whidborne, 1893.
Dielasma, King, 1859.
Epithyris, King, 1850.
Cranæna, Hall, 1893.
Dielmasmina, Waagen, 1882.
Hemiptychina, Waagen, 1882.
Beecheria, Hall, 1893.
(?) Cryptacanthia, White and St. John, 1867.
Terebratula, Klein, 1753.
Lampas, Meuschen, 1787.
Terebratulina, d'Orbigny, 1847.
Agulhasia, King, 1871.
(?) Disculina, Deslongchamps, 1884.
Liothyrina, Œhlert, 1887.
Liothyris, Douvillé, 1880.
Eucalathis, Fischer and Œhlert, 1890.
(?) Dyscolia, Fischer and Œhlert, 1890.
Glossothyris, Douvillé, 1880.
Pygope, Link, 1830.
Propygope, Bittner, 1890.
Zugmayeria, Waagen, 1882.
Rhætina, Waagen, 1882.
Dictyothyris, Douvillé, 1880.
Cœnothyris, Douvillé, 1880.
(?) Hynniphoria, Suess, 1858.

Family Terebratellidæ, King.

Terebratella, d'Orbigny, 1847.
Waltonia, Davidson, 1850.
Terebratalia, Beecher, 1893.
Laqueus, Dall, 1870.
Frenula, Dall, 1871.
Trigonosemus, Kœnig, 1825.
Kingena, Davidson, 1852.
Lyra, Cumberland, 1816.
Terebrirostra, d'Orbigny, 1847.
Magellania, Bayle, 1880.
Waldheimia, King, 1850.
Neothyris, Douvillé, 1880.
Macandrevia, King, 1859.
Zeilleria, Bayle, 1878.
Fimbriothyris, Deslongchamps, 1884.
Antiptychina, Zittel, 1883.
Microthyris, Deslongchamps, 1884.
Ornithella, Deslongchamps, 1884.
Eudesia, King, 1850.
Flabellothyris, Deslongchamps, 1884.
(?) Orthotoma, Quenstedt, 1871.
Aulacothyris, Douvillé, 1880.
(?) Epicyrta, Deslongchamps, 1884.
(?) Plesiothyris, Douvillé, 1880.
(?) Camerothyris, Bittner, 1890.
(?) Orthoidea, Frirer, 1875.
Dallina, Beecher, 1893.
Ismenia, King, 1850.
Magasella, Dall, 1870.
Tropidoleptus, Hall, 1857.
Platidia, Costa, 1852.
Morrisia, Davidson. 1852.

Family Magasidæ, d'Orbigny.

Magas, Sowerby, 1816.
Bouchardia, Davidson, 1849.
Mühlfeldtia, Bayle, 1880.
Megerlia, King, 1850.
Rhychora, Dalman, 1828.
Rhynchorina, Œhlert, 1887.
Mannia, Dewalque, 1874.

Family Stringocephalidæ, Dall.

Stringocephalus, Defrance, 1827.

Family Megathyridæ, Œhlert.

Megathyris, d'Orbigny, 1847.
Argiope, Deslongchamps, 1842.
Cistella, Gray, 1850.
Zellania, Moore, 1854.
Gwynia, King, 1859.

Sub-order HELICOPEGMATA or SPIRIFERACEA, Waagen.

Family Atrypidæ, Dall.

Hallina, N. H. Winchell and Schuchert, 1892.
Protozyga, Hall, 1893.
(?)Cyclospira, Hall, 1893.
Zygospira, Hall, 1862.
Anazyga, Davidson, 1882.
Orthonomæa, Hall, 1858.
Catazyga, Hall, 1893.
Glassia, Davidson, 1882.
Atrypina, Hall, 1893.
(?) Clintonella, Hall, 1893.
Atrypa, Dalman, 1828.
Karpinskia, Tschernyschew, 1885.
Gruenewaldtia, Tschernyschew, 1885.

Family Spiriferinidæ, Davidson.

Cyrtina, Davidson, 1858.
Bittnerula, gen. nov.
Thecocyrtella, Bittner, 1892.
Cyrtotheca, Bittner, 1890.
Spiriferina, d'Orbigny, 1847.
Suessia, Deslongchamps, 1854.

Family Spiriferidæ, King.

Spirifer, Sowerby, 1815.
Choristites, Fischer de Waldheim, 1825.
  Trigonotreta, Kœnig, 1825.
  Brachythyris, McCoy, 1844.
  Fusella, McCoy, 1844.
Delthyris, Dalman, 1828.
Reticularia, McCoy, 1844.
Martinia, McCoy, 1844.
Martiniopsis, Waagen, 1883.
Cyrtia, Dalman, 1828.
Syringothyris, A. Winchell, 1863.
Ambocœlia, Hall, 1860.
Metaplasia, Hall, 1893.
Verneulia, Hall, 1893.
Mentzelia, Quenstedt, 1871.

Family Nucleospiridæ, Davidson.

Nucleospira, Hall, 1858.
Dayia, Davidson, 1882.
Hindella, Davidson, 1882.
Whitfieldella, Hall, 1893.
Hyattella, Hall, 1893.
(?) Camarospira, Hall, 1893.

Family Cœlospiridæ.

Anoplotheca, Sandberger, 1856.
  Bifida, Davidson, 1882.
Cœlospira, Hall, 1863.
Leptocœlia, Hall, 1859.
(?) Anabaia, Clarke, 1893.

Family Retziidæ.

Rhynchospira, Hall, 1859.
Homœospira, Hall, 1893.
Ptychospira, Hall, 1893.
Trematospira, Hall, 1857.
Parazyga, Hall, 1893.
Retzia, King, 1850.
Uncinella, Waagen, 1883.
Eumetria, Hall, 1864.
Acambona, White, 1862.
Hustedia, Hall, 1893.

Family Uncitidæ, Waagen.

Uncites, Defrance, 1825.

Family Meristellidæ, Waagen.

Merista, Suess, 1851.
  Camarium, Hall, 1859.
Dicamara, Hall, 1893.
Meristella, Hall, 1860.
Charionella, Billings, 1861.
(?) Pentagonia, Cozzens, 1846.
  Goniocœlia, Hall, 1861.
Dioristella, Bittner, 1890.

Family Athyridæ, Waagen.

Meristina, Hall, 1867.
  Whitfieldia, Davidson, 1882.
Glassina, Hall, 1893.
Athyris, McCoy, 1844.
  Spirigera, d'Orbigny, 1847.
Cliothyris, King, 1850.
Actinoconchus, McCoy, 1844.
Seminula, McCoy, 1844.
Spirigerella, Waagen, 1883.
Kayseria, Davidson, 1882.
Anomactinella, Bittner, 1890.
Amphitomella, Bittner, 1890.
Pomatospirella, Bittner, 1893.
Tetractinella, Bittner, 1890.
Pentactinella, Bittner, 1890.
Diplospirella, Bittner, 1890.
Euractinella, Bittner, 1890.
Pexidella, Bittner, 1890.
Anisactinella, Bittner, 1890.

Family Koninckinidæ, Davidson, 1853.

Koninckina, Suess, 1853.
Amphiclina, Laube, 1865.
Koninckella, Munier-Chalmas, 1880.
Thecospira, Zugmayer, 1880.
Amphiclinodonta, Bittner, 1890.
Koninckodonta, Bittner, 1893.

Incertæ Sedis.

Eichwaldia, Billings, 1858.
    Dictyonella, Hall, 1867.
Aulacorhynchus, Dittmar, 1871.
    Isogramma, Meek and Worthen, 1873.

Alphabetical Index to Genera and Subgenera.

Names in *italics* are synonyms.

ADDENDA.

Orthotropia, Hall, 1894.

(For illustration see Palæontology of New York, Vol. VIII, part 2, pl. 84, figs. 3–7.)

Elongate biconvex shells with short hinge, erect cardinal area, open delthyrium, deep muscular scar in the pedicle-valve forming a sessile spondylium from the anterior extremity of which extends a short median septum. There is also a median septum in the brachial valve.

Type, *Orthotropia dolomitica*, Hall. Niagara group.

Torynifer, Hall, 1894.

(For illustration see Palæontology of New York, Vol. VIII, part 2, pl. 84, figs. 34, 35.)

Shells athyroid in external aspect, but with a well-defined cardinal area and a distinct spondylium in the pedicle-valve supported by a median septum.

Type, *Torynifer criticus*, Hall. Lower Carboniferous (St. Louis group).